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FAO Fisheries Reports, No. 99 FIRM/R99 (En)

REPORT OF THE FAO TECHNICAL CONFERENCE ON MARINE POLLUTION AND ITS EFFECTS ON LIVING RESOURCES AND FISHING

Rome, Italy, 9 - 18 December 1970

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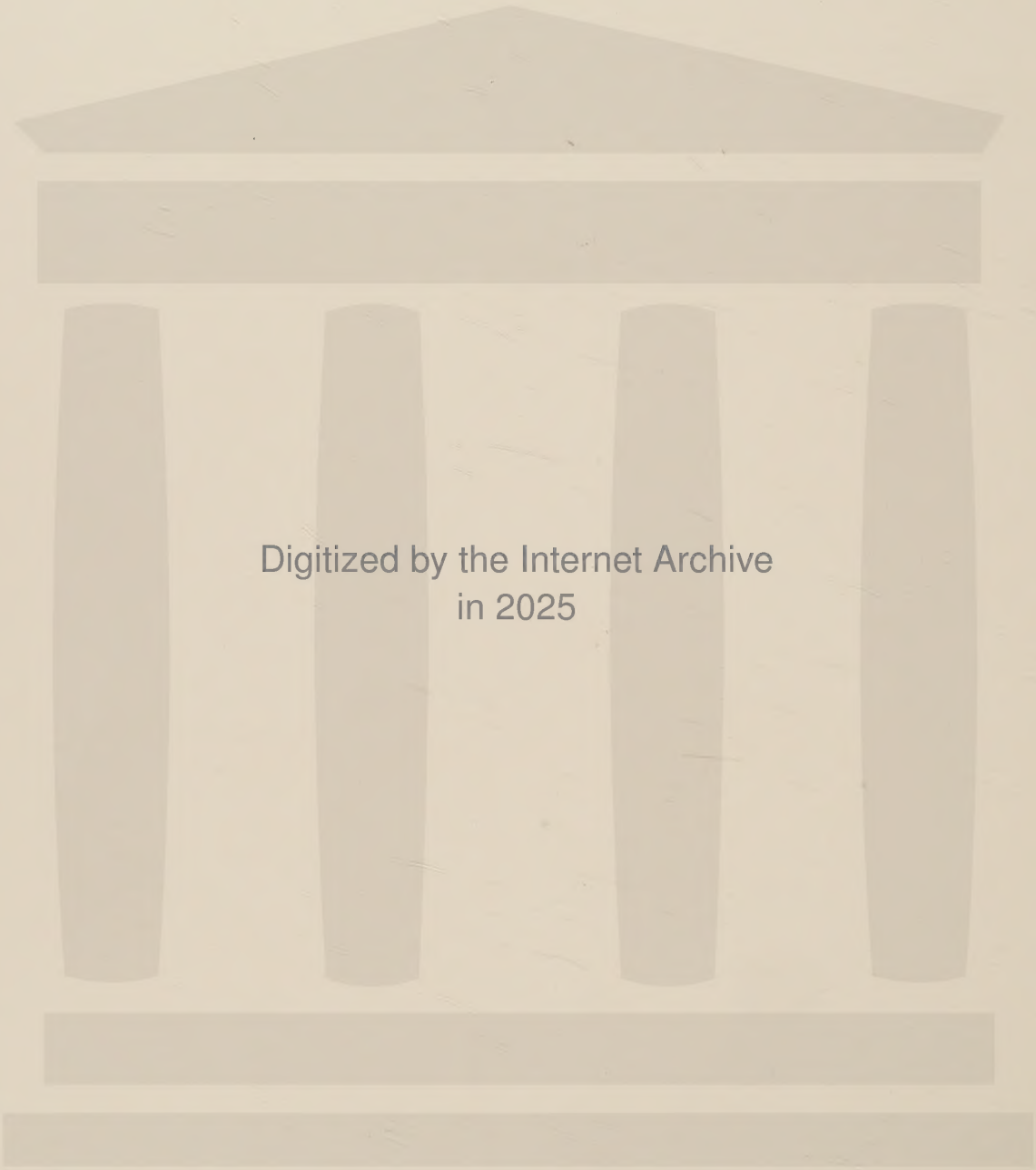
ROME, 1971



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REPORT OF THE FAO TECHNICAL CONFERENCE ON MARINE POLLUTION AND ITS EFFECTS ON LIVING RESOURCES AND FISHING

Rome, 9-18 December 1970

Prepared by

Fishery Resources Division
Department of Fisheries

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, June 1971

PREPARATION OF THIS REPORT

This volume contains the revised and amended version of the Draft Report and General Conclusions as well as the abstracts of the contributions from the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing, Rome, 9 to 18 December 1970, which were distributed to the participants during the Conference. The report was compiled and edited by Dr. M. Ruivo, Director of the Fishery Resources Division, who acted as the Secretary of the Conference, and by the Assistant Secretaries Dr. D. Sahrhage, Dr. G. Tomczak and Dr. L. Andrén, of the Marine Biology and Environment Branch of the Fishery Resources Division. Dr. M. Waldichuk (Canada), the General Rapporteur of the Conference, assisted in its preparation.

The views expressed in the report and in the contributed papers are those of the authors and participants and are not necessarily those of the Food and Agriculture Organization of the United Nations.

It is intended to publish the Proceedings of the Conference, including the full text of most of the contributed papers, in book form as a co-publication with Fishing News (Books) Ltd., London.

The report of the Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment, which was held in conjunction with the Conference, will be issued as a supplement to this report (FAO Fish. Rep., 99 Suppl. 1).

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1 INTRODUCTION

As human populations multiply and industrialization increases and diversifies, the problem of the pollution of the environment becomes more critical. Not least of the environmental problems is water pollution. The seas and oceans, which cover 70 percent of the world's surface and offer one of man's great hopes for future food supplies, are not exempt from the menace of pollution. Pollution problems mount as populations move to the coasts seeking the amenities and recreational opportunities of the sea-shore, as well as the convenience and advantages to be found there for certain kinds of industry. With the growing use of sea lanes for commerce, the ever-increasing size and variety of cargo ships and tankers and the use of the sea-bed for mineral extraction, the threat of pollution to the marine environment from deliberate or accidental release of noxious materials from ships and cargoes becomes more acute every day. The sea is polluted by fall-out from the atmosphere. Authorities are reacting to public pressures to maintain clean inland and coastal waters and are moving their wastes further offshore by pipelines, tankers and barges. Except for the disposal of oil, there is little if any control over the discharge of wastes into international waters. Because of the enclosed character of some seas, the wastes may not be rapidly diluted and dispersed by natural processes. Depending on the nature of the waste, and on the transport by currents and winds, it may drift to the coasts of other nations. Drifting out to sea, it may even adversely affect the open sea environment for plants and animals.

The menace of pollution to the marine environment has been brought into sharp focus by a number of events in recent years. Fall-out from nuclear tests and the discharge of radioactive wastes from nuclear reactors have brought increasing protest from a radioactivity-sensitive public. The TORREY CANYON disaster, the Santa Barbara oilwell seepage, and many other accidents of smaller scale have demonstrated the devastation that can arise in coastal waters and on beaches from the uncontrolled entry of oil into the sea. Although in the latter incident, the shores of only one nation were involved, the former affected at least two nations and could have been detrimental to many more had it occurred in the North Sea, the Baltic or the Mediterranean. The detection, far from any obvious sources, of pesticides in the marine environment and in the marine organisms has brought to light the devious ways in which dangerous materials can be transmitted through the marine food chain and transported long distances by physical and biological processes. The synthesis of new compounds for a variety of purposes and their release into the environment before they are fully tested on aquatic organisms, presents potential harm to living marine resources. Moreover, the possible synergistic effects of this multiplicity of toxic substances can be far more severe than single-factor bio-assays would suggest.

Pollution is an increasing problem and we should be preparing ourselves for events to come. We must assemble "baseline" information on essentially unpolluted areas of the marine environment against which we can measure the effects of pollution. Subtle changes can only be recognized by means of a long series of painstaking observations. The exploration and exploitation of non-living resources, both advancing rapidly in many coastal seas, are bound to have certain undesirable effects - at least locally - on water quality and bottom characteristics. Studies organized under the International Biological Programme (IBP) have been examining trends in marine waters receiving a variety of pollutants. There is a particular need to obtain data on existing conditions in unpolluted tropical waters, about which so little is known, where exploitation is planned or is proceeding.

At this point, it should also be pointed out that there are certain developments on the positive side. There is a tendency in industry to develop means of recovering valuable elements and compounds from wastes before these are discharged. Sometimes it is also possible, as in the case of "pollution" by warm water discharges, to turn the "waste" product to advantage. At least some countries are adopting practices which might reduce the immediately harmful effect of dumping (by putting wastes further offshore, and in deeper waters or in more effective containers) and minimize the risk of pollution by accidents. All these factors, however, require further scientific and economic study, development, and controlled application. This is particularly true where, as in dumping and deep pipeline construction, we are concerned essentially with balancing one use of the ocean resource against its other uses.

Among these other uses must now be counted not only traditional fishing activities, but also the great potential for mariculture in coastal waters. In the development of this potential, the maintenance of "water quality" may be of paramount importance.

Apart from the effects on the living resources, fishing operations are affected in a variety of ways by pollutants. Trawlers may tear their nets on discarded automobile bodies and on other large, heavy objects - even on abandoned cables and gears discarded by other fishermen. They may "catch" in their nets explosives and containers of dangerous chemicals. Nets can be fouled by oil and by other similar substances. The means of controlling these nuisances and hazards to fishermen are a vital requirement for the continuing exploitation of the sea for commercial and sport fisheries.

Lastly, pollution - and the public's fear of pollution - can have other adverse effects on the economy of the fishery industries. Marine products may be tainted or poisonous, and hence unsalable, or quality impaired and prices depressed. To regain lost quality, processing and treatment costs may be added, and the price to the consumer is correspondingly increased. Public knowledge that some fish and marine products are affected by pollution can lead to a buyers' reaction against all similar products.

It was in this context that FAO decided to organize a Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. The programme of this Conference was prepared with the assistance of the FAO Advisory Committee on Marine Resources Research (ACMRR) and of the IMCO/FAO/UNESCO/WMO/WHO/IAEA Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). Contacts were maintained during the preparatory work with the various other UN organizations concerned, either directly or through the Sub-Committee on Marine Science and its Applications of the UN Administrative Committee on Coordination (ACC).

These consultations led to the convening, as a special session of the Conference, of a Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment, which was organized by FAO with the support of UNESCO, IAEA, SCOR and WMO. As part of FAO's collaboration with the International Biological Programme (IBP), arrangements were also made for a special session to facilitate discussions among experts attending the Conference and involved or interested in research projects dealing with pollution under the IBP Marine Communities (PM) Section.

As proposed by the Conference, FAO has already transmitted to the Secretariat of the UN Conference on the Human Environment (Stockholm, 1972) the Conclusions and Recommendations adopted during the meeting and which were also made available to the Second Session of the Preparatory Committee for the Conference on the Human Environment (Geneva, February 1971). This material has also been transmitted to all the agencies participating in the ACC Sub-Committee on Marine Science and its Applications (viz. UN, UNESCO, WHO, WMO, IMCO and IAEA), with a view to developing a coordinated action programme.

Particular attention was also given to this matter by the IOC Bureau with the Consultative Council at its 12th Session (Bordeaux, March 1971) in connection with the plans for the Long-term and Expanded Programme of Oceanic Exploration and Research (LEPOR), and later on by the Advisory Committee on Marine Resources Research (ACMRR) during its Sixth Session (Rome, March 1971).

FAO is also taking into account these Conclusions and Recommendations in preparing its Programme of Work and Budget for the next biennium (1972-73), as well as for its Medium-term Programme, and bringing them to the attention of the regional fisheries bodies (e.g. CARPAS). As part of the follow-up of the Conference, steps are being taken to promote technical assistance to developing countries in the field of marine pollution in connection with the protection of the living resources and fisheries, and for the training of specialized personnel, either through international or bilateral aid sources.

2 SCOPE AND OBJECTIVES

The scope of the Conference was broad and included in principle the consideration of all types of pollutants, from whatever source, and in all sea areas, including estuaries, with reference to the following definitions of the term "marine pollution": 1/

> "Introduction by man of substances into the marine environment resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities."

Investigations of fresh-water pollution were not included, with the exception of particular studies of methods and techniques also relevant to marine problems.

The general objectives of the Conference were:

(a) to bring up to date and concentrate in one place as much as possible of the world-wide experience and knowledge on marine pollution in relation to the ocean and its living resources;

(b) to provide a forum for exchange of useful scientific and technical information on marine pollution problems and their solution;

(c) to identify situations - especially those having international aspects - where there is danger of damage, particularly irreversible damage, to fisheries and to the marine environment, as a basis for action to prevent or alleviate pollution;

(d) to consider ways of preventing or stemming pollution in such waters as lagoons, mangrove swamps and coastal inlets, especially where there is potential for mariculture;

(e) to focus attention on scientific problems where international cooperation and coordination are required as a basis for management;

(f) to identify expected future trends in marine pollution and discuss the need for and content of "baseline" studies against which changes in the marine environment can be measured;

(g) to provide scientific and technical guidelines for the international control of marine pollution in the interests of the protection of the marine environment and its living resources;

(h) to provide guidelines for future FAO programmes, including the pertinent activities of its Committee on Fisheries;

(i) to provide a synthesis which would be useful in the context of the UN Conference on the Human Environment to be convened in 1972 in implementation of UN General Assembly Resolution 2398 (XXIII).

3 ORGANIZATION OF THE CONFERENCE

The Conference was organized in seven Sections covering the following subjects:

I - Marine pollution in the world today;

II - Behaviour and fate of pollutants in the marine environment;

1/ This definition was considered by a SCOR/ACMRR Working Group and accepted by the IOC Working Group on Marine Pollution as well as by GESAMP

III - Effects of pollutants on the biology and life cycle of marine organisms;

IV - Ecosystem modifications and effects on marine communities;

V - Technical aspects of minimizing pollution and countering its effects;

VI - Effects of pollutants on quality of marine products and effects on fishing;

VII - Scientific basis for international legislative control of marine pollution in the interests of protection of marine resources and fisheries.

The time-table of the Conference is given in Appendix 1 and a list of the Officers of the Conference and the Secretariat in Appendix 2.

The Conference was attended by more than 400 participants (listed in Appendix 3) from 57 countries. Although mainly scientists, the participants also included administrators, lawyers, technologists and representatives from industries. Twenty three international organizations were represented. The attendance by a number of specialists from developing countries was facilitated through assistance from the international development agencies of Sweden (SIDA), Denmark (DANIDA) and Canada (CIDA) which provided FAO with funds for this purpose.

A Steering Committee under the Chairman of the Conference and consisting of the four Vice-Chairmen, the seven Conveners of the Sections, the General Rapporteur and the Secretary of the Conference was formed to assist with policy and organizational matters.

A great number of contributions were submitted to the Conference in the form of review papers (by invited authors) and experience papers. In order to allow for a maximum time for discussions, the Convener of each Section gave an extensive introduction on the subject, bringing out the significant highlights in each contribution, integrating the major aspects, and providing a coherent picture of the problem under review.

The subsequent discussions, during which authors had an opportunity to make supplementary comments, were focussed around a number of selected themes. In each Section a number of conclusions and recommendations were elaborated which are given in the Section reports (see Chapter 7). Based on the conclusions and recommendations of all Sections, a series of general recommendations were adopted (see Chapter 6).

During the Conference, various technical and semi-popular films, kindly provided by international organizations, private industry and information centres, were shown on two evenings (10 and 15 December). These films illustrated various aspects of pollution, including the pollution of continental and marine waters through untreated sewage effluents, industrial waste, pesticides, damming and diversion of streams flowing into coastal areas, oil spillage from carriers, and the actual poisoning of human and domestic animals through consumption of contaminated fish and shellfish from mercury compounds (Minimata, Japan). Films were presented showing methods and equipment for dispersing oil at sea through mechanical processes and for sinking oil by applying amine-treated sand. Also shown were large-scale operations for recovering oil from surface waters of coastal areas and from sunken oil carriers. One film illustrated efforts in one country to monitor coastal areas for possible contamination from industrial and radioactive waste disposals; another showed the potential for the future use of satellites in agricultural, oceanographic, and natural resources studies.

4 OPENING CEREMONY

Dr. A.W.H. Needler, the Chairman, opened the Conference and introduced Mr. Roy I. Jackson, the Assistant Director-General (Fisheries).

In his opening address (Appendix 4) Mr. Jackson welcomed the participants to the Conference on behalf of the Director-General of FAO and on behalf of the Department of Fisheries. He thanked Dr. Needler for assuming the Chairmanship of the Conference.

Mr. Jackson noted that a time has been reached in human affairs when a revolution against pollution must be undertaken. The world's production of fish has doubled in the last decade and may double again in the next 15 years. It must be recognized, however, that an increase in catch, and the acceptability of the product, depend on a healthy marine environment. He stressed that we must accept the fact that for some time to come populations will continue to increase, and that consumption of resources will increase exponentially in relation to population growth. Economic costs of production must be measured not only in terms of tangibles, but also in terms of previously ignored costs difficult to quantify, and in terms of social effects. By using an ecological approach, it is possible to promote industrial and agricultural development without unduly adverse effects on the quality of the environment. FAO is particularly aware of this conflict in interests because of its dual role in promoting development and in the management of the marine environment and its renewable resources. Scientific research must encompass ecological investigations involving chemistry, physical oceanography, maritime meteorology and biology.

The need for trained specialists on pollution control in developing countries prompted FAO to make a special effort to invite scientists to this Conference from these countries. FAO intends to institute a training programme in this field.

In conclusion he noted that this Conference will give FAO guidance on marine activities for its own Programme of Work and will serve as background for the UN Conference on the Human Environment, to be convened in Stockholm in 1972.

The Chairman, in his address said that it is now necessary to examine the pollution problem and to lay plans for strengthened activities by governments, scientific institutions and international agencies in this field. The Chairman then introduced the Conveners and Rapporteurs of the Sections.

At the end of the Opening Session, Dr. M. Ruivo, the Secretary of the Conference, gave information and guidance on the organization of the meetings, film shows, facilities and social events.

5 PLENARY SESSIONS

Four Plenary Sessions were held under the Chairman of the Conference at various stages of the meeting (see time-table in Appendix 1) for the consideration of the draft reports from the seven Sections and for the discussion and adoption of general conclusions and recommendations from both the Plenary and the various Sections.

During the First Plenary Session the Conference considered the Draft Report of the Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment, [2] a summary of which was given by its Convener, Dr. E.D. Goldberg. Appendix 5 contains a summary of the results of the Seminar.

The Conference noted that the report of the seminar will be published as a part of the Proceedings. The Conference was also informed that a Manual for the Detection and Measurement of Pollutants in the Marine Environment will be produced. It was recognized that such a manual would be most useful for training purposes.

The Conference considered in particular the two resolutions submitted to it by the Seminar (see Appendix 5) which were taken into account in the related general conclusions adopted by the Plenary.

There was further discussion particularly concerning an early warning system. The opinion was offered that monitoring of toxic substances would be facilitated if advance information was made available before such substances are introduced into the oceans.

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[2] Published as FAO Fisheries Reports, No. 99 Suppl. 1

During further Plenary Sessions the Conference examined the draft reports of the seven Sections and approved the various recommendations with some amendments. One Plenary Session was mainly devoted to a discussion of a draft resolution prepared by a drafting group under Dr. G. Humphrey (Australia) which had been set up as a result of discussions in Section IV. The resolution concerned with the problem of human population growth and industrial development with uncontrolled waste disposal was amended and finally adopted as a general recommendation.

The Conference also approved a number of other general recommendations in the Fourth Plenary Session. The developing countries stressed that the adequate training of specialists in aquatic pollution research and control was urgently needed. The general recommendation concerning assistance to developing countries was amended accordingly.

6 GENERAL CONCLUSIONS AND RECOMMENDATIONS

6.1 Action to prevent and combat marine pollution

The Conference expressed its serious concern at the increasing pollution of the marine environment and its harmful, and at times lethal, effects on living marine resources, and was of the opinion that more expert knowledge should be gained in order to understand, as a basis for action, the immediate and long-term consequences of pollution which threatens the marine environment; believed that the increases in uncontrolled industrialization and in other waste-producing activities constitute, in the absence of new and increased remedial measures and preventative action, the major threat to the success of any measures for alleviating marine pollution, and that this threat is aggravated by the increasing world population; recognized marine pollution to be a part of the overall problem of the pollution of the human environment and, therefore, recommended urgent action to prevent and combat pollution on international, regional, national and individual levels in order to minimize effects on the marine environment, its living resources and fishing.

6.2 Pollution control at source and recycling

The Conference, noting that, in addition to the inputs from marine outfalls and dumping, marine waters are polluted from the atmosphere and the land, via land runoff and river discharges, recognized the urgent need for a coordinated approach to marine pollution control and firmly recorded their view that the only satisfactory base for control is at the source, i.e. where the potential pollutant is first released, whether it be into the air, land or sea. In most instances this means applying restraint, by local action under national jurisdiction, so as to restrict releases to levels and to methods accepted as potentially harmless. In some instances, and indeed also for economic reasons, the possibility of waste-recycling techniques should be explored. The Conference recommended that research on techniques of treatment, recovery and recycling of wastes in industry should be encouraged as widely as possible.

6.3 Dumping

One particular instance of pollution concerned deliberate off-shore dumping in the high seas. This received special attention, as presenting problems not only in the general context of pollution, but also as presenting physical problems and even danger for fishermen, and indeed potential international problems in so far as such dumping is done extra-territorially. The Conference strongly recommended that deliberate dumping of toxic and solid wastes on recognized and potential fishing grounds and other shallow water areas be prohibited. It was also recognized that, even in respect of carefully controlled dumping in deep waters, much further information is still required on important aspects such as rates of degradation of the materials, and especially rates of transport and diffusion of toxic substances in such circumstances, both physically in the aquatic medium and biologically through the food-web. The use of dumping in deep trenches where in-folding may occur should be further investigated. The Conference recommended that FAO, in collaboration with IOC, be asked to encourage and speed up research in both fields as a matter of urgency.

6.4 Mercury pollution

The Conference was aware of the accumulation of mercury by aquatic organisms and of the tragic consequences of mercury pollution to human health, particularly as exemplified by the so-called "Minamata disease" in Japan. Moreover, because of the hazards of mercury poisoning and the banning of contaminated fish, the fishing industry in many parts of the world has suffered severe economic losses. The Conference was informed that technology is now available virtually to eliminate mercury losses from industries where this metal is used. Therefore, the Conference recommended that action be taken by governments to require advanced techniques be adopted for mercury recovery in all factories producing mercurial products or using mercury or its compounds as catalysts, cathodes or for other purposes in production. It further recommended that seed-dressings, slimicides and other mercurial compounds be replaced at the earliest possible time by other non-mercurial substitutes.

6.5 Oil pollution

The Conference recognized that there will be a continuous increase in the amount of petroleum and its products transported over and under the sea by ships and pipelines, and exploited from the sea bed, and recognized that in spite of measures taken by IMCO and industry concerned, it would be very difficult to eliminate all accidental or deliberate releases into the sea from these sources, and that releases from land-based installations and through the atmosphere are also taking place in substantial amounts; noted with concern the damage already done to water fowl and to some aquatic organisms; the potential hazards of the accumulation of dangerous chlorinated hydrocarbons, such as DDT and polychlorinated biphenyls, as well as other aromatic hydrocarbons in oil films and the possible toxicity to aquatic life and possibly to man; and potential damage by oil to sensitive ecosystems, such as those of coral reefs and of arctic waters, and therefore recommended an immediate increase in research at national or international laboratories, to examine more closely the scientific problems associated with oil pollution effects on the marine environment and its living organisms, so that action can be taken to avoid dangers that could arise, and furthermore, that FAO together with IOC, in consultation with their advisory bodies, including GESAMP, coordinate such research and, in cooperation with appropriate agencies, foster necessary action.

6.6 Pollution by chlorinated hydrocarbons

The Conference was informed about the increasing volume of persistent chlorinated hydrocarbons, such as DDT and polychlorinated biphenyls, entering the marine environment and its living organisms through water discharges, land runoff and the atmosphere. Their accumulation by organisms and their direct toxic effects, leading to loss of reproductive ability in fish and birds at the top of the food chain, and to mortality of certain aquatic organisms were noted with serious concern. The economic losses to fisheries, because of banning of fish contaminated by these substances, is an economic burden to fishermen and society. The Conference recommended, therefore, that FAO, with assistance from its advisory bodies, request member nations to increase research on ecologically less harmful substitutes for the control of pests, and that better control of losses into the environment of polychlorinated biphenyls, and also of other potentially hazardous chemicals be immediately instituted.

6.7 Education

The Conference recognized the importance of educating the public on the aspects of pollution in relation to conservation and management of the marine environment and the living resources and urged FAO, in association with other appropriate bodies, to use their influence to encourage governments to stimulate increase of public awareness of conservation and environmental management through appropriate coverage of such matters in their educational curricula, keeping in mind the special needs of developing countries.

6.8 Pollution and ecosystems

Recognizing the urgent need for improved understanding of the marine ecosystems if the potential effects of pollutants are to be properly assessed, the Conference recommended that FAO, in cooperation with appropriate international organizations, encourage research in this field, by biologists, physicists, mathematicians and others in collaboration, with the object of establishing realistic models of natural conditions and especially those conditions for which predictions of the fate of pollutants and their effects on members of the food-web will be required.

6.9 Monitoring pollution and its effects

In considering a global system of marine pollution monitoring the first objective must be to provide data and information on the state and trends of pollution of the world oceans, with a view to facilitating management measures and their enforcement. The Conference noted and agreed with the suggestions made by the Seminar on Methods of Detection, Measurement and Monitoring of Pollution in the Marine Environment (Rome, 4-10 December 1970), and recommended that, as a first step, existing national monitoring programmes, particularly in areas with a risk of heavy pollution, should be encouraged to cooperate in pilot regional monitoring exercises, such as are being organized under ICES at present for the North and Baltic Seas. Such regional projects will provide valuable experience both in necessary techniques and in management of monitoring; they will at the same time facilitate contacts between the relevant laboratories regarding the essential basic research, the substances to be monitored, the sampling procedures and the analyses of pollutants.

As all nations should, in the long run, participate in monitoring of marine pollution, the Conference recommended that FAO, together with IOC, and their relevant advisory bodies should use all possible means to promote the development and adoption of intercalibration, and suitable methods for monitoring, and should further assist in establishing national marine pollution programmes in developing countries, especially in training scientists and technicians, in expanding existing specialized laboratories or, when necessary, setting up new laboratories performing international functions, and in intercalibrating and/or standardizing sampling and analytical equipment.

In order to facilitate the establishment of a marine pollution monitoring programme on a world-wide basis, the Conference further strongly recommended that a preliminary exploratory survey for evaluation of the state of pollution of the world ocean should be made by international cooperation at the earliest possible date, in order to establish the levels of various substances (natural and artificially introduced) in the water column, together with their accumulation in the plankton, the benthos, the fish and the sediments. Special attention would need to be paid to the coastal zone. Substances that should be surveyed include especially metals (mercury, lead, cadmium, copper and zinc), petroleum-derived halogenated hydrocarbons, including polychlorinated biphenyls, and some other aromatic hydrocarbons. The survey designed by the Study Group on Critical Environmental Problems (SCEP) may serve as an example for the planning of such a survey, but it would need to be extended and repeated as facilities and information develop.

In recommending this preliminary assessment, to be followed by further surveys of the state and health of the ocean, the Conference recognized that the initiating and developing of a global system for marine pollution monitoring must take place through close coordination and collaboration among the international agencies responsible for monitoring of the marine, terrestrial and atmospheric components of the earth's environment. Only through such close cooperation can all the information essential for man's further evolution on the planet earth - in equilibrium with the remainder of the ecosystem - be provided.

With these important matters in mind, especially the need for a greater understanding of the scientific basis for rational management of living marine resources as a matter of urgency, the Conference recommended that FAO should strengthen its work and capability in the field of ecology in the closest collaboration with intergovernmental and non-governmental scientific organizations. Recognizing the need for the establishment of closer contacts between workers in the field of research and control of marine pollution, the Conference also recommended that FAO, in collaboration with other relevant international organizations, should continue and increase its activities in the exchange and retrieval of marine scientific information in general, but concerning pollution in particular, including registers and tabulations of marine pollutants and the compilation of lists of experts and institutions active in this field. The Conference recommended further the encouragement and support of arrangements for the production of manuals on monitoring and minimizing pollution. Such manuals should be issued in various languages for the use of marine scientists and engineers and in relevant training courses.

6.10 Assistance to developing countries

In general, the Conference recognized that marine pollution is of growing concern to public welfare and opinion, and to the fisheries industries, in developing as well as in developed countries. It recognized further that some tropical areas are widely occupied by ecosystems which are particularly susceptible to ecological stress, especially by pollution, and therefore, being aware of the urgent need for improved understanding, with resultant projects for monitoring and minimizing pollution in those areas, noted that it is an international duty to help developing countries to be equippped to deal with immediate problems in the field of marine pollution, and to protect their aquatic environment and the future of their fisheries, and to assist them to develop their economies and industries in a harmonious way and without damaging their natural resources and environment. The Conference therefore recommended that FAO should initiate negotiations with the United Nations Development Programme (UNDP) in order to ensure that financial support for the maximum international technical assistance be provided, in present and future projects in environmental research related to marine pollution and its effects on the living resources and fishing and its control. FAO should also encourage and mobilize the maximum assistance in this field from bi- and multilateral sources.

The Conference recommended further that FAO should promote and coordinate training courses necessary for the specialization in various fields of marine pollution in connection with the protection of the living resources of the sea (research, planning, etc.), and that FAO should approach UNDP and countries in a position to facilitate and assist with the necessary training in these disciplines; FAO should also explore the possibility of establishing laboratories to serve different regions, dealing with analysis of special types of pollutants, and providing on-the-job training; and should provide advice, on request, to member countries on matters concerning management of the marine environment and protection of fisheries from pollution until these countries have their own personnel and facilities.

6.11 UN Conference on the Human Environment

Recognizing that the oceans covering two-thirds of this earth's surface tend to be used as the universal sink, and that it may well be impossible to redress any major disturbance to them, the Conference urged that FAO should bring all these recommendations immediately to the attention of the UN at its Conference on the Human Environment, to be held in Stockholm in 1972, and to the other international agencies directly concerned, so as to ensure the maximum appreciation of the importance for man of maintaining the biosphere as a whole, and the oceans in particular, in a state in which can can thrive and evolve, in equilibrium with the physical environment and the other organisms on which he is dependent for so many of his economic needs and acceptable standards for human life.

7 REPORTS OF SECTIONS

7.1 Section I : Marine pollution in the world today

Convener: Dr. H.A. Cole

Rapporteur: Dr. A.J. Gilmour

Review papers: R-3, 7, 11, 16, 18, 19*, 20, 24, 25, 27, 32, 34*

Experience papers: E-6, 49, 72, 85, 97, 107

Referred from other sections: R-14, 23

E-37, 73

7.1.1 Introduction

It was anticipated that this section would develop for the Conference the necessary background against which the more detailed problems of the subsequent sections could be discussed. The majority of the papers presented to the Conference came from the more industrially developed countries, especially in the northern hemisphere. Some other papers provided information, which was supplemented by oral statements, on the pollution situation in certain developing countries or on areas having chronic or special pollution problems. Review papers were not available for the southern regions of South America and Africa, for Oceania (excluding Australia), nor for India and its neighbours.

The review and experience papers covered a very wide spectrum of regional activities in marine pollution research and management, and for this reason, five topics were suggested around which discussion was orientated.

7.1.2 Themes for discussion

(a) Special requirements of sensitive ecosystems, e.g. coral reefs, mangrove areas, coastal lagoons, areas of importance for mariculture

(b) Regional trends in marine pollution and development of monitoring schemes

(c) Establishment of ecological baseline studies, both nationally and regionally

(d) Patterns of national organization for marine pollution research. Fundamental and applied studies; involvement of industry; needs of regulatory authorities

(e) Offshore dumping in the high seas

7.1.3 Summary of discussion

7.1.3.1 Special requirements of sensitive ecosystems

Discussion started on the development of Arctic areas, with particular reference to the oilfield development in Arctic North America, and to the apparent lack of information on which adequate control measures designed to protect natural communities of the region could be based. Some of the facets of Arctic communities which make these regions sensitive were

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* Available as abstract only

mentioned briefly, e.g. the absence of planktonic dispersal phases in arctic bottom animals. The effects of oil on coral reef systems also merit special attention. Preliminary indications are that where the reef is permanently submerged the risks of damage are slight. However, in the presence of a continuous thick film of oil, interruption of the photosynthetic cycle of the zooxanthellae could occur and lead to further secondary effects. Occasional observations of coral reefs continuously submerged in Persian Gulf waters which were exposed to refinery effluents also showed no immediate effects. Reference was made to damage to other components of the reef ecosystems including fish kills in the Pacific Islands. Excess of nutrients may cause changes in the reef ecosystem. As an example, it was noted that a reef in Hawaii was being destroyed through blanketing green bubble algae, as a result of fertilization of coastal waters. It was pointed out that funds devoted to tropical research in general, and coral reefs in particular, are insufficient.

The vulnerability to pollution of lagoons, and of other coastal embayments, with a growing need for their use for mariculture was emphasized. Some support was expressed for the concept of classification of coastal areas in respect of their proposed utilization. Great care would be required in framing and administering pollution legislation based on such an approach, owing to the combination of both political and technical problems inherent in such schemes. In particular, it might be politically undesirable to designate areas for waste disposal in perpetuity.

7.1.3.2 Regional trends in marine pollution and the development of monitoring schemes

The impact of atmospheric and river-borne pollutants was emphasized, and the consequent need for a coordinated approach and regionally based studies was made apparent. Some international organizations, e.g. FAO and WHO, and regional bodies, e.g. ICES, have been supporting these activities and fruitful cooperation is already established in the North Sea, the Baltic and the Mediterranean. Critical reviews of other parts of the world have not yet been made owing to the lack of adequate machinery. Such machinery is an essential prerequisite for the development of regional monitoring schemes.

The concept of monitoring was discussed and the views of the Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment were given by the convener of the Panel on the design of a global marine monitoring system. Mention was also made of the steps being taken by the Intergovernmental Oceanographic Commission to elaborate the technical basis for monitoring within the framework of the IOC Long-term and Expanded Programme of Oceanic Research (LEPOR). A global marine monitoring system must be broad enough to include a variety of the components of the ecosystem and should be developed on the basis of national and regional systems. This presents major problems in standardization of methods;

there is a need for immediate action in this direction by international organizations. Monitoring is required to understand the chronic effects of pollution and to forecast future risks.

Some discussion was devoted to the unsatisfactory nature of the definition of "pollution" adopted for the conference; but the consensus favoured retaining a general description related to protection of the environment for the beneficial use by humanity. Within such a generalized definition, the environmental quality requirements must nevertheless be rigorously defined for each particular situation. The use of regional units, based on biophysical or ecological criteria, allowing a flexible approach to pollution management was supported.

7.1.3.3 Establishment of ecological baseline studies, both nationally and regionally

The discussion was started on the question as to whether ecological baseline studies were essential for effective pollution control at this stage of knowledge. The conference recognized the difficulties of establishing useful baselines in view of the inherent variability of ecological systems, but nevertheless emphasized the need for such studies, particularly in the light of the chronic effects of long-term exposure to persistent pollutants. Physiological criteria were recognized as essential components of baseline studies. If the use of ecologically defined management regions is adopted as an administrative concept in pollution control, then such baseline studies are an integral part of that approach. Irrespective of how sophisticated chemical monitoring techniques become, they will not provide information on the status of the biological components of an ecosystem.

A number of speakers expressed concern lest such biological monitoring schemes concern themselves exclusively with commercially important species and pointed out that the early recognition of the far-reaching effects of certain pesticides depended on observations on reproduction in birds. The conference accepted the need for broad, multiple-index studies, without diverting attention from the legislative and technical control of the sources of pollution.

The use of ecological baseline studies on an international or regional basis again raises the problem of standardization of methods. Some discussion took place regarding the usefulness of marine pollution information centres, and it was considered that these should be developed nationally and regionally, and lead toward an international service. The role of FAO in the development of reference systems, particularly to assist developing countries, was also reviewed, and its expansion to cover marine pollution adequately was encouraged.

7.1.3.4 Patterns for national organization for marine pollution research

The prospects of waste-recycling techniques were drawn to the attention of the Conference. Recycling, where feasible, could not only reduce or prevent a pollution problem, but could also facilitate a more rational conservation of natural resources. It was felt that more research should be encouraged on these problems, both to solve the technical difficulties and to overcome the socio-economic problems of implementation. The position of responsible industrial management, and its attitude to funding research, was discussed. In Europe, North America and Australia, joint or complete funding of mission-orientated research by industry is common and this appeared to be a positive response to public opinion. A conservation-educated public would exert a more rational influence on policy makers. Attention was drawn to the role that international organizations such as FAO, as well as non-governmental scientific organizations, could play in encouraging governments to include environmental management in general educational curricula.

7.1.3.5 Off-shore dumping in the high seas

In connection with the recovery by trawlers of drums containing toxic chemicals from the North Sea the necessity for providing a sound scientific basis for the control of deep-sea dumping of noxious materials was noted as a matter requiring urgent attention. Mention was made of the recent suggestion that such containers be dumped into the deep trenches where they will eventually be buried by geophysical in-folding. The legislative position regarding control of extra-territorial dumping by nationals appears ill-defined in many countries, and this presents a potential international problem.

7.1.4 Concluding remarks by the Convener

The Convener, in summing up the results of the Sectional Proceedings, concluded that pollution problems fell into three groups:

(i) Those requiring local action, e.g. by placing restraints on industry or development. This is by far the largest group. Such problems lay within national jurisdiction, in estuaries and coastal waters. These areas were important, not merely as the main production areas for shellfish but often also as nursery grounds for young fish. Their potential importance for mariculture was also recognized. These were also the areas of greatest importance for recreational purposes.

(ii) Those requiring regional cooperative action, e.g. (a) in enclosed or semi-enclosed seas such as the Baltic or Mediterranean; or (b) at national boundaries, such as in the Gulf of Finland, or (c) where large river systems carry wastes derived from several countries, e.g. the Rhine and the St. Lawrence.

(iii) Those requiring global international action of which oil is perhaps the best known example. There are, however, other categories of pollutants which are included here: (a) persistent and wide-spreading materials such as chlorinated hydrocarbons; (b) materials transported in substantial quantities through the air, such as mercury and lead; and (c) materials of all kinds dumped in international waters.

Such a classification, while not perhaps fully comprehensive, would serve as a basis for waste management and the development of pollution control.

7.1.5 Conclusions and recommendations

7.1.5.1 The Conference recognized the need for a coordinated approach to marine pollution control, taking into account the contributions from the atmosphere and river discharges in addition to those from marine outfalls and dumping.

7.1.5.2 The Conference stressed the need for further regional studies of pollution situations on patterns similar to those followed by ICES in the North Sea and the Baltic, and the Group of Experts from GFCM/ICSEM in the Mediterranean. It was recommended that, where there is no appropriate regional body, FAO should take the initiative and should arrange for expert guidance to be available. Where surveys have already been made, they should be up-dated from time to time.

7.1.5.3 The Conference recommended that, in enclosed and semi-enclosed seas (such as the Baltic, North Sea and Mediterranean); in sea areas spanning national boundaries; and where large river systems draining several countries discharge, pollution control should be organized on a regional cooperative basis, based on joint scientific evaluation. Subsequent monitoring on the effects of measures adopted to control pollution should also be arranged cooperatively employing standardized methods.

7.1.5.4 For the purposes of pollution control there may be advantages in differentiating between estuarine and coastal waters according to their principal usage, defining, for example, areas to be set aside mainly for fishery purposes (e.g. shellfish cultivation) or recreation (bathing and water sports) and others, where a lower standard of water quality may be accepted to accommodate industrial waste or sewage discharges after treatment. Such a classification system should be dynamic, however, moving towards an eventual elimination of pollution.

7.1.5.5 Where large areas are being considered in pollution surveys, it is useful to classify them into regions according to biophysical or ecological characteristics as was done in the survey of estuarine and coastal pollution in the U.S.A.

7.1.5.6 The Conference recognized the serious lack of the ecological information needed to make assessments of pollution effects in tropical areas, e.g. in relation to such sensitive ecosystems as coral reefs, mangrove areas and coastal lagoons. There is also a serious lack of such information in the Arctic; therefore, it is recommended that additional research should be encouraged.

7.1.5.7 The Conference further stressed the need to consider standardization of the methods used in baseline ecological studies related to pollution control.

7.1.5.8 The Conference recommended that FAO should request appropriate agencies to continue to encourage research on the technology and on institutional constraints associated with the recycling of wastes.

7.1.5.9 In suitable regional areas consideration should be given to the desirability of assembling and distributing factual data on pollution in an appropriate form such as a Sampling Yearbook to facilitate their analysis and evaluation.

7.1.5.10 The Conference recommended that FAO should assist in the urgent task of introducing environmental management into educational curricula so as to facilitate the implementation of marine pollution control.

7.2 Section II : Behaviour and fate of pollutants in the marine environment

Convener:	Dr. J. Joseph
Rapporteur:	Dr. J.E. Portmann
Review papers:	R-4, 5, 31, 35
Experience papers:	E-1, 19, 20, 29, 35, 37, 43, 44, 46, 48, 57, 69, 79, 98
Referred from other sections:	R-10, 18, 26 E-15, 24, 25, 38, 42, 47, 51, 61, 72, 76, 96, 104

7.2.1 Introduction

Pollutants enter the sea by a variety of routes, for example, from the air, rivers, pipes and by dumping from ships. Since the subsequent behaviour and fate of these substances depends upon a variety of factors, some physical, others biological or chemical, the problems to be faced in making predictions of their behaviour and fate are considerable. Predictions can usually be made concerning one or more aspects separately. However, since all of the factors are inter-dependent, the reliability of a prediction made by considering all aspects together will be limited by our knowledge of the least understood variable. The Conference considered the present state of knowledge of various parameters which could affect the behaviour of a pollutant in the light of the papers presented and the discussions generated. These considerations led to a number of conclusions and recommendations.

7.2.2 Themes for discussion

(a) General considerations and the possible use of mathematical models for the prediction of the behaviour of pollutants

(b) The possibility of extending these models to include chemical and biological parameters

(c) The possible behaviour of material dumped in deep sea areas and the prediction of such behaviour and possible means for confirming the accuracy of such predictions

(d) Many materials discharged to the marine environment become flocculated or adsorbed on particulate matter. How important are these processes in the removal of pollutants from the water?

(e) Consideration of the role of sediments as a reservoir of pollutants and in possible chemical processes e.g. ion exchange and oxidation-reduction

(f) Considerations of the role of marine animals and plants in the uptake of pollutants, their metabolic alteration and also their transport

(g) Proposals and recommendations of the session

7.2.3 Summary of discussion

7.2.3.1 Physical behaviour

Pollutants are transported and distributed in the marine environment by currents, waves and turbulent mixing processes. These will differ for different physical states of the pollutant. At the present time, there is a considerable amount of data available concerning the physical behaviour of pollutants on discharge to the sea. The information essentially refers only to the surface waters. Although the way in which diffusion processes operate are not fully known, the way in which pollutants will behave in the marine environment under the influence of various wind and turbulence conditions away from immediate coastal effects can now be predicted with a certain degree of accuracy. A number of mathematical models have been constructed to enable such predictions to be made. These have been tested by comparison with the observed behaviour of a pollutant in field experiments, using a variety of tracer techniques, e.g., rhodamine B and radioactive tracers. These tests indicate that under many conditions, there is good agreement between the predicted and observed dispersion rates in surface waters.

There is, however, a suggestion that under certain conditions the rate of diffusion does not increase steadily with size of the system but that as the diffusion field increases beyond a certain size, there is a marked reduction in the dependence of the rate of diffusion on further increase in size of system. This indicates the dangers in drawing conclusions from small-scale short-term experiments. When

the boundaries are grossly irregular, as in coastal waters, the mathematical models require modification to allow for these factors. A number of proposals have been made on ways of overcoming this problem, and one of these is to make use of a hydrodynamical model in which coastal irregularities are included in the boundary conditions. It is, therefore, important when coastal areas are involved to obtain as much data as possible on the various local conditions such as run-off, topography, locally induced currents, etc.

The Conference considered that the behaviour of a pollutant on discharge from an outfall was a somewhat specialized case which required rather more sophisticated models than those necessary for open sea problems. Although the problems involved do seem to be relatively well understood, since so many factors are involved, e.g., density of plume, size of outlet, etc., prediction remains very difficult. It is possible, nevertheless, with the exception of particularly refractory materials, to design outfalls by a combination of theory and empirical data, which will allow pollution prevention on beaches. In special cases where a thermocline exists, it is possible to design an outfall so that the plume does not rise to the surface. In the special case of a sewage discharge, factors can be introduced into the models to allow for the die-off of bacteria. Thus, predictions can be extended to probable bacterial distribution at some distance from the outfall, e.g., on bathing beaches.

7.2.3.2 Physical behaviour in combination with chemical and biological behaviour

The chemical behaviour of many pollutants and the way in which they may be altered or taken up by marine organisms is in many cases at least partially understood. Mathematical models can be constructed which represent such behaviour. However, in order to be able to predict the full fate of a pollutant, with a view to protecting the environment, the problem is to try to combine the various models in order to describe and predict the combined physical, chemical and biological behaviour of the pollutant.

Some workers are already beginning to investigate these possibilities. One preliminary approach considers that the biological factor will behave as a particle with a vertical migration pattern. The Conference considered that, although limited at present by the working speed of present computers, it would be possible as bigger and more efficient computers become available to introduce many more factors. Models could be constructed to take account of all the various parameters, but extensive testing of the model with appropriate chemical and biological data would be necessary. Although much information is available, there remains the problem, particularly with the biological data, of selecting the best set of data for testing the models. The Conference concluded that there was a need for collaboration of biologists, chemists and physicists with mathematicians in solving these problems.

7.2.3.3 Deep water processes

The discussions indicated that at the present time it is not possible to accurately predict either the physical behaviour or the chemical or biological fate of a pollutant in the deep waters of the ocean. It has to be proved that the present mathematical models for dispersion can be used for the prediction of dispersion in deep waters and how in such areas the constants may have to be changed. Furthermore, it is known from work in the field of marine radioactivity that chemical behaviour is different in deep waters. Knowledge of bottom currents was considered inadequate and demands further investigations.

For technical reasons present tracer methods are not readily applicable to deep waters. There appears to be a complete lack of information regarding deep-sea organisms which might concentrate certain chemicals. It was realised that there would always be a need for waste disposal and that we have to prove carefully the possible capacity of the ocean to accept wastes of different kinds. However, in order to be able to predict the possible consequences and to calculate the amount which could safely be disposed of in deep waters, it is especially necessary to have a better knowledge of the physical, chemical and biological conditions near the bottom of the oceans.

7.2.3.4 Sedimentation processes

Many pollutants, particularly metals and halogenated hydrocarbons, are readily adsorbed onto suspended particulate material. If the particulate material settles on the bottom, these materials may become locked in the sediments. There is evidence to suggest that in certain cases as much as half of the nutrients discharged in rivers may become bound up in the sediments. Under certain circumstances, these scavenging processes may be considered to be beneficial, since potentially biologically hazardous materials may become inactivated in the sediments.

On the other hand, sedimentation of a pollutant may lead to long-term problems in an area, since the benthic population may be drastically altered. Alternatively, biochemical decomposition may take place, with subsequent release of noxious materials such as sulphides. In certain special instances, e.g., mercury, the pollutant may even become altered to a more biologically hazardous form. When quantities of organic matter decompose on the sea bed, the pH of the sediments is liable to be reduced, although in the absence of oxygen, various processes tend to counteract this.

Many materials may not be permanently bound in a sediment, and recent investigations indicate that up to 75% of certain metals may be released from the upper layers of a sediment. The Conference also noted that with certain substances, e.g., mercury, the suspended material may contain considerably higher proportions than the bottom sediments, as a result of different size of particles and matrix type. On the other hand, some organic materials, e.g., DDT and PCB's, tend to be

more firmly bound, although some recycling may be possible. The amount of material in suspension depends very much on the degree of turbulence, and in shallow water areas recycling will be increased in times of storms with even small changes in wind strengths, bringing about considerable resuspension of sedimentary materials. It was clear that knowledge on the role of sediments in the fate of a pollutant is at present inadequate and that more studies will be necessary before the effects of suspended and sedimentary particulates on pollution are fully understood.

7.2.3.5 Degradation

Many pollutants, including components of crude oil, will be degraded by the action of bacteria yeasts and other microflora either in the water or in the bottom sediments. The rate of degradation is related to the presence of other microflora, additional nutrients, the chemo-physical conditions and, in certain instances the presence of other microflora. The Conference noted that in general the rate of bacterial degradation of a pollutant is dependent not only on the bacterial flora present, but also upon the amount of organic substrate available. Thus, in deep waters, bacterial degradation may be very slow owing to limiting amounts of substrate even though bacteria are present. (Bacteria have been found in large numbers even in very deep water, but little is known of their in situ activity.) However, even in the presence of adequate concentrations of substrate and bacteria, degradation in deep waters has been shown to be slow. The Conference considered that these low rates of decomposition of organic pollutants would be particularly important in considerations of quantities and materials which can be safely dumped in deep water areas.

7.2.3.6 Fate of particular materials

The fate of several pollutants was considered by the Conference in some detail.

a) Radioactivity

Although not a special concern of the Conference, the field of radioactivity was considered in the way that it could offer valuable experience in both scientific and organizational fields.

The Chairman briefly informed the Conference of the activities of IAEA in the field of radioactivity. The IAEA has the statutory mandate to establish or adopt standards of safety for the protection of health and minimisation of the danger arising from the peaceful uses of atomic energy. It is establishing a register of radioactive waste disposal to the sea. With the assistance of the Government of Monaco and the Musée Océanographique, the Laboratory for Marine Radioactivity is presently working on a review of present knowledge in the field of radioactive waste disposal in the sea, and the intercalibration and standardization of measuring methods. The coordinated intercalibration programme involves more than 60 laboratories distributed around the world.

The Conference noted that when a radioactive material is to be discharged to the sea studies are made of dispersion before and after discharge. The Conference also noted that different organisms have different rates of uptake for different radioactive nuclides and this led to a discussion on the possible use of indicator species which, because they concentrate a particular chemical, might be useful in the detection of pollutants. This would be particularly useful for low-concentration pollutants, for instance, in the study of the fate of highly toxic compounds.

b) Oil

The behaviour and fate of oil in the marine environment was considered in some detail. Automatic sen..ing and possibly monitoring methods were discussed briefly. It was recognized that many areas are severely contaminated by oil and the suggestion was made that this should be quantified by analysis if possible. There is considerable evidence available today to suggest bacterial and other routes of decay. It was noted, however, that certain poly-nuclear aromatics some of which are recognized as being commonly present in the marine environment, are only degradable under certain conditions. For example, benzpyrene decomposition is dependent particularly on the available light, but also on temperature and oxygen levels. Thus, in deep waters, degradation of such substances would be extremely slow.

c) Mercury

The fate of mercury in the marine environment is complicated by the fact that not only is it liable to be concentrated by marine organisms but there is considerable evidence of biochemical alteration to the more toxic methyl mercury. Aerobic methylation of mercury is known to occur; and there is now some indication that ionic mercury can be methylated under anaerobic conditions. The uptake of mercury by plants is considered to be largely a surface adsorption effect, but fish appear to take up mercury both via their gills and food. There is considerable evidence of cycling of mercury within the bio-geochemical system, and although all mechanisms are not fully understood, various cycling processes have now been suggested.

d) Enteric organisms

The fate of coliforms and other enteric organisms in the sea was briefly considered by the Conference. Coliforms are known to have a fairly rapid die-off in sea water and since the rates of die-off have been measured it is possible to use counts of coliforms in order to estimate the rate of dispersion of sewage plumes. The rate of die-off or inactivation of viruses, on the other hand, is a relatively new field of study. The information available to date suggests that viral inactivation processes may be considerably slower than those for coliforms. The rate of inactivation appears to be increased with increase in bacterial numbers. There appears also to be an antagonism between naturally-occurring marine viruses and enteric viruses.

There may be some measure of chemical inactivation as well. If the sea water is rich in collodial suspended material, then the virus may be protected by adsorption. Coliphage, which are occasionally suggested as a means of measuring viruses, die more rapidly and fluctuate in numbers in a way which does not always reflect viral numbers.

7.2.4 Concluding remarks by the Convener

The task for the scientists at the present time is to prove the possible capacity of the oceans to accept wastes of different kinds and, if any, how big it is. We have to look for representative parameters, their critical values and for methods of measuring and controlling pollutants in the different oceanic areas. The governments and the competent national and international organizations need our help for preparing regional or global regulations to avoid dangerous pollution of the sea. This required us to make predictions. One of our efforts should be therefore to develop mathematical or other models not only for the physical but also for the biological and chemical processes which influence the behaviour and fate of pollutants in a marine environment. This would facilitate very much our task of prediction especially of dangerous concentrations. It is a difficult but surely not hopeless problem through patient work in laboratories and in the ocean itself to determine with increasing accuracy the necessary physical, biological and chemical information which might be put in a computer programme. This task obviously requires broad and intensive international collaboration. That this is possible is, however, already demonstrated by the international coordinated research programme in marine radioactivity studies of the IAEA.

7.2.5 Conclusions and recommendations

The Conference recommended that:

7.2.5.1 FAO be requested to seek the cooperation of other appropriate interested organizations in the setting up of a group of specialists in biological, physical, chemical and mathematical disciplines with a view to establishing mathematical models covering all aspects of the prediction of a pollutant's fate in the sea.

7.2.5.2 In view of the lack of knowledge of physical, chemical and biological processes in the deep water zones and the increasing interest in the use of these areas for waste disposal, FAO should be requested to encourage and bring to the attention of other organizations concerned, particularly IOC, the need for investigations into these matters by member nations and interested scientific and technical organizations and laboratories.

7.2.5.3 As sedimentary processes are only partially understood at the present time, increased investigations into the role of these processes in the cycling or inactivation of pollutants should be encouraged.

7.2.5.4 In view of the need to survey various pollutants to establish objectively the levels of pollution, particularly in the seas of less developed areas of the world, FAO should investigate the possibility of setting up such studies. This should be arranged in collaboration with other organizations concerned, and with the participation of local laboratories and advisory bodies, in order to provide a useful baseline and indicate areas which might later require monitoring.

7.3 Section III : Effects of pollutants on the biology and life cycle of marine organisms

Convener:	Prof. M. Fontaine
Rapporteur:	Dr. L. Hannerz
Review papers:	R-2, 8, 9, 26, 30
Experience papers:	E-3, 7, 12, 13, 14, 16, 17, 23, 27, 31, 32, 33, 34, 40, 45, 50, 56, 59, 61, 63, 64, 66, 67, 68, 75, 76, 81, 88, 90, 91, 92
Referred from other sections:	R-1, 6, 10 E-4, 11, 20, 21, 22, 38, 39

7.3.1 Introduction

A large amount of background material was presented to this Section in the form of review and experience papers. These were synthesized in a comprehensive introductory review and supplemented by a great number of oral statements. The Convener emphasized that association of field observations with experimental work in the laboratory was considered of basic importance. Research work should generally start in the natural environment, either in zones which are expected to become polluted in the foreseeable future but where the ecological conditions can still be studied prior to pollution, or in zones already polluted where the changes in the biocoenosis and the presence of pollutants in the water, sediments and organisms should be studied. Toxicological experiments would be particularly useful, as a second step, for establishing or for confirming presumed correlations between the modification of the environment by toxic substances and changes occurring in the population within affected areas. Understanding of the mechanism of action of such pollutants on physiological functions of the organisms could also be improved in this way. Moreover, such experimentation could be used to foresee, for the purposes of prevention, the dangers to which aquatic life could be exposed in the case of discharges of various pollutants. A third step would be the return to observations in the natural environment, in order to test the results obtained in the laboratory under the combined influence of environmental factors and the biological elements of a biocoenosis.

7.3.2 Themes for discussion

(a) Choice of marine organisms for experimental studies of the biological action of pollutants

(b) Tests of lethal toxicity

(c) Knowledge of the biological action that is required for the elaboration of sublethal toxicity tests:

  (1) on bacteria and plants

  (2) on animals

    (i) nutrition
    (ii) respiration
    (iii) osmoregulation
    (iv) reproduction - development - growth
    (v) nervous system and behaviour
    (vi) cellular physiology

(d) Studies of the biological effects of pollution in the natural environment, in the light of the results obtained in the laboratory (synergetic effects and features of the biotope)

7.3.3 Summary of discussion

7.3.3.1 Marine test organisms for experimental studies and indicator species for ecological effects of pollutants

The discussion clearly reflected the considerable complexity of this problem. One of the main difficulties appears to be the paucity of knowledge of biological parameters concerning the large majority of species which may be used as test organisms. It was pointed out that there is still a tendency to limit experimental work to species which are easy to culture, and that often these species are not adequate for toxicity studies, in view of their resistance to pollution.

The criteria for choosing test animals appear to vary largely with the types of experiments and their objectives. The importance of using a wide spectrum of organisms, as far as possible representing different trophic levels, was emphasised. The criterion of ecological significance of the organism should always be taken into account, but unfortunately, not all ecologically significant species may be suitable test organisms.

Indicator species should indicate the effects of waste releases, and thus give warning of unwanted changes. Such organisms must fulfil certain criteria: adequate numbers in the area affected; stationary; sufficiently long-lived, and affected by pollution. It seems preferable that such species also be large enough to provide material for the study of histological changes and for chemical analysis on the content of various accumulated substances.

The food chain was noted as a means of concentration of pollutants at higher trophic levels, and in this connection, phagocytosis of bacteria by cells of coelenterates and other lower invertebrates was believed to be of particular importance. Several speakers pointed out the desirability of using test organisms from non-polluted areas, as they would not have adapted to the pollutant used in the experiment. Studies of the mechanisms of action of pollutants on specific physiological functions may require different kinds of organisms in each case. In this connection, the paucity of information on the physiology of marine organisms and on chronobiological mechanisms was pointed out. As a result, an important criterion for choosing test organisms was considered to be the amount of information available on a species. Several speakers mentioned the desirability of choosing species of economic importance as test animals, but it was considered that the choice among such organisms would be rather limited. It was noted, however, that the effects of pollution in many cases might be reflected earlier in non-commercial benthic organisms than in economically important species which are generally migratory and belong to higher trophic levels.

Regarding the usefulness of various taxae as test organisms, several speakers referred to their practical experiences in expressing their views. Especially noted were certain benthic invertebrates, especially polychaetes, which are relatively stationary and reflect not only the conditions at the time of sampling, but also those which have existed before. Such species as Capitella capitata are useful as indicators of polluted areas, being cosmopolitan and permitting comparisons between many regions of the world. The advantages were pointed out of comparing the relative densities of two species, such as Capitella capitata and Nereis grubei, which react differently to pollution. Other useful test organisms are: marine bacteria, in view of their easy culture and sensitivity to pollutants; larvae of some fish species which, besides being economically important, are biologically better known and - as with all young stages of organisms - are more sensitive to pollutants than the adults; microscopic algae, as they are easy to cultivate, and because pollutant effects on such cultures can easily be measured by the influence on their reproduction rate; hydrozoa in which the effects of pollutants could be measured by counting the number of polyps in the culture; macroalgae which would also be particularly well suited as indicators; and molluscs which are of special interest in view of their capacity to accumulate pollutants, and sensitivity to the mechanical action of certain pollutants. It was noted that mariculture projects could provide an excellent opportunity for the study in the field as well as in the laboratory of the action of pollutants.

It was concluded that the range of organisms presently used for toxicity tests should be considerably expanded. Moreover, research should be focussed on certain species of organisms, which would satisfy the various basic objectives and requirements of experimental research, such as abundance of the species, sedentarism, minimum life-span, high sensitivity to pollutants and a size sufficiently large for making biochemical and histological analyses. In this connection, reference was made to the work of the Panel on Monitoring Organisms of the Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment, which has already identified a number of criteria for the selection of organisms for such purposes.

The Conference recommended that a working group on the choice of test organisms be established and that a special effort be made by FAO to make available up-to-date information on the biology of such species. In addition, an informal discussion group was formed during the Conference which considered this subject, and its members agreed to forward comments on this matter to the Chairman of the above-mentioned Seminar Panel.

7.3.3.2 Tests of acute toxicity

The criterion first and currently most employed when testing the effects of pollution is acute toxicity. The results are often expressed as the minimum dose or concentration required to kill 50% of the test population in a given time, e.g., 48 or 96 hours.

The discussion in this context concentrated largely on the considerable variations in the toxicity of a pollutant, depending on: (1) the physico-chemical conditions of the water used in the experiments (e.g. presence of chelating agents, degree of ionization, hardness, and salinity, which is negatively correlated with surface tension, etc.); (2) the physico-chemical condition and behaviour of the pollutant (which may occur in different forms such as ionic, particulate, organically bound, emulsified or as a surface film, and may be chelated or adsorbed on suspended organic matter), and (3) the condition and behaviour of the test organisms (i.e. the amount of toxic material actually penetrating into the organism, the degree of their retention and rate of excretion, the adaptation which might have been developed by test animals at an earlier stage to the pollutants tested, etc).

On the basis of the above considerations, several methodological questions were raised. The need was emphasized for providing, together with the results of the tests, precise data on the physico-chemical environment and on the condition of the organisms tested. Most of the presently available test results were considered useless, in fact, for the purpose of predictions, because they were not substantiated by this kind of information. It was found desirable to extend the duration of tests of lethal toxicity, as mortality may sometimes occur only after the termination of the test. The active concentration of the toxic agent in the water during the test, as well as the amount actually penetrating into the organisms, was considered to be of vital importance and should be measured. Several speakers pointed out the advantages of continuous flow-tests over batch culture-tests. The former facilitate maintenance of more stable conditions in the chemical environment and a better control - at least in the case of micro-algal cultures - of the population size. There may be some limitations of this method, however, in cases where test organisms are used which are sensitive to water flow. It was suggested that not only the LD 50 but also the LD 0 and the LD 100 application factors be given with the result of the tests. This would be particularly important in the case where advice on permissible levels of waste dumping is required. Evidence was given of the great variation in radio-sensitivity of certain test organisms. This showed the broad spectrum of species that must be examined in order to find out which of them should be particularly monitored in a biocenosis exposed to radioactive pollution.

The need was expressed for a better comparability of test results, and it was suggested that the problem of standardization of methods be included in the terms of reference for the working group proposed under recommendation No. 4.1 (see p. 33).

The Chairman of European Inland Fisheries Advisory Commission (EIFAC) informed the meeting that his organization was aware of the multiplicity of fresh-water toxicity terminology and is establishing a working group (under its Sub-commission No. III) for the purpose of preparing a multilingual glossary of terms used in this field. EIFAC would welcome the idea of adding to this group a member with experience in the marine field, who might help make the glossary comprehensive for fresh and marine waters. This suggestion received general acceptance.

Concerning the usefulness of lethal toxicity tests, some speakers pointed out the large variability of application factors for such tests, according to the nature of the pollutant. Quantitative toxicity tests should be aimed at measuring biological parameters, such as reproduction rate, rather than mortality. Thus lethal toxicity tests may be used primarily as a basis for establishing a warning system of acute toxicity accidents, rather than for determining biological significance.

7.3.3.3 Knowledge of the biological action of toxicants required for the elaboration of sublethal toxicity tests

In most cases, the limits for permissible concentrations of pollutants in the marine environment must be set on grounds other than their acute toxic effects on the organisms. Of primary importance in this connection are the chronic and sublethal effects of the pollutants, including avoidance reactions of fishes. Many substances are detected and avoided by fish at very low concentrations. Other sublethal effects may result, either from the gradual accumulation of substances to levels where they have biological effects on organisms, or from the continued stress exerted by pollutants. Among long-term effects, it is also necessary to consider those on genetics of marine organisms. However, there is very little information on this subject.

Numerous forms of organic pollution lower the oxygen concentration. If we consider only the limit which allows marine organisms to survive for a short period, we generally obtain a low lethal threshold for oxygen; however, for normal nutrition, growth and reproduction, a higher oxygen content than the minimum lethal threshold is needed. Only long-term physiological tests, for example, on respiratory function, nutritional behaviour, or fecundity, can show the critical level of oxygen concentration at which the organism ceases to be normal.

The need for extending the duration of sublethal tests was also emphasized during the discussion, firstly because of data such as those showing the slow action of pollutants and the possibility of their accumulation in the

organisms, and secondly from a chronotoxicological point of view : the variation in sensitiviy of test organisms according to time rhythm. These rhythms seem to exist at all levels of organization (living organisms as a whole, as well as tissues and cells), and they are an expression of what has been called the "biological clock". The effect of pollution on this biological clock deserves special consideration for future studies.

In order to make the assessment of sublethal effects more accurate, it was recommended that not only biochemical but also histological control analysis be applied whenever possible. The desirability of establishing standard measures for the effect of pollutants on certain species was voiced, and in this connection, the assessment of water quality by the degree of opening of oyster shells was mentioned as an example.

a) Bacteria and plants

It is well known that a number of pollutants, e.g. of food and paper industries, favour the proliferation of bacteria and lower fungi, while others inhibit them. Some studies demonstrate the stimulating effect of viruses on the growth of marine bacteria. In this connection, the positive effect of oil on the development of certain populations of oil-degrading marine bacteria was mentioned.

As regards the studies of sublethal effects on algae, the attention of the meeting was drawn to the action of numerous pollutants, notably DDT at concentrations as low as 4 parts per billion, on the photosynthetic activity of phytoplankton. It has been demonstrated that DDT also inhibits cellular division in marine phytoplankton. Examples were given of several planktonic algae in which the reproduction is stopped or altered by minor doses of DDT, dieldrin or endrin, but sensitivity varies greatly between species. The large specific variations in resistance towards radionuclides was stressed, particularly with Nitzchia cells showing high resistance to Cs - 137. On the other hand this alga is very sensitive toward organomercurials used as fungicides. Organic mercury compounds are more toxic than inorganic ones. Bacteria play a prominent role in conversion of the inorganic form to the toxic methyl-mercury. Crude oil constituents have a retarding effect on cellular division of phytoplankton. Still more toxic are some detergents used for cleaning the beaches after a massive pollution. Certain metallic elements, such as copper and molybdenum, and organic materials, like humic acids and vitamin complexes, can either stimulate or inhibit algal development.

Also mentioned were the effects of hydrocarbons and detergents on the cellular membrane of algae, leading to a penetration of the pollutant into the cell and to the extrusion of cellular fluid. A high sensitivity of some macroalgae, like Enteromorpha, to copper at low concentrations was reported from Sweden; but at higher concentrations, a chelating effect was observed which protects the algae from the pollutant.

With regard to methodological aspects, the advantages and disadvantages were examined of using pure clone-cultures or a genetically-mixed material as test organisms in flow-culture of microalgae. Although genetically homogenious, clone-cultures may involve the risk of not representing the average sensitivity of the species to the tested pollutant.

The meeting was informed about extensive work in the U.K. on cultivation of macroalgae. which has led to the development of a new practical method of using seaweeds as test organisms in continuous flow-culture.

b) Animals

(i) Effects on nutrition

It was noted that a large number of pollutants can act on different nutritional phases by: reducing the food resources of the environment; altering certain sensorial mechanisms which change the abilities of the animal to detect its prey; acting on the behaviour of the consumer, including its appetite; or bringing about increased catabolism and excessive loss of substance. A number of examples were given of effects of this kind, brought about, single or combined, by various types of pollution (i.e., malnutrition caused in mussels as a result of reduced food consumption and production of mucous faeces or pseudo faeces following contamination by flocculated iron hydroxide; action of pesticides on the food consumption and the feeding period of fishes; action of several pollutants on the taste papillae of fishes, and hence, on their nutritional behaviour, etc.).

The effect of certain pollutants is a function of the nutritional condition of the organisms. Thus, the compounds PCB and DDT accumulated in the blubber of seals, when they are liberated and released into the blood stream during starvation may give rise to serious physiological effects. On the other hand, it was also pointed out that bacterial pollution of urban origin can favourably affect the nutrition of certain filtering organisms and/or of detritus feeders.

Numerous pollutants probably act on the intermediate metabolism, and at least in certain cases through the neuroendocrine system, but this mechanism has not been sufficiently studied in marine animals. The intermediate metabolism is not only interesting in connection with the physiopathology of the animals concerned, but also in view of its general role in the biocenosis. The possibility, under certain circumstances, of bacterial methylation of inorganic mercury has been demonstrated. Fish also seem capable of methylating the several forms of mercury introduced into the organism.

As shown by several experiments with mussels and fish the degree of toxicity, and the rates of accumulation and excretion of certain pollutants, appear to be dependent

on their physico-chemical condition, concentration, environmental factors, and on the pathway through which they are introduced into the organisms.

The importance of studying the metabolism of toxic agents throughout the food chain was emphasized. In this connection, the results of some experiments suggest that marine polychaetous annelids may play an important role as a food chain link for entry of DDT into fish.

(ii) Effects on respiration

It was shown that pollutants can act on the respiratory functions of the organisms directly and indirectly through a variety of mechanisms. These include: clogging of the gills through a purely mechanical action; modification of the branchial cells (by certain metals), sometimes causing histological changes in the gill tissue; and diminution of the oxyphoretic capacity of the blood. The latter may happen through a reduction of concentration of the respiratory pigment in the blood, of the number of red blood cells particularly, damage to the haematopoietic tissue and possibly even through qualitative modification of the blood respiratory pigment (i.e. oxygen dissociation curve). Further research is required.

Examples of the effects of low oxygen concentrations on the physiology and behaviour of some organisms were given, such as disturbances of the reproductive function and migration patterns. Oxygen consumption and efficiency of oxygen up-take were shown to be reduced in the Pacific salmon under such conditions. It was reported that salmon has been found to survive at rather low oxygen concentrations for limited periods, by resorting to anoxybiotic metabolism as a provisional source of energy. However, this was accompanied by deleterious metabolic effects (accumulation of lactic acid in the blood, excretion of this lactic acid through urine, loss of energy, depletion of glycogen reserves in the muscles, etc.)

Attention was drawn to the need for studying particularly the effect of fluctuations in temperature on respiration and on other physiological functions. With regard to values of oxygen tolerance determined under experimental conditions, it was pointed out that they would tend to be too low, if the whole life cycle of an organism was taken into consideration. On the other hand, experimental values might be too high as a result of increased metabolism due to the stress of experimental conditions.

(iii) Effects on osmoregulation and ionic regulation

Some pollutants, such as methylparathion, endrin and methoxychlor, were shown to alter the concentrations of various cations in the fish Sphaeroides maculatus, indicating an effect on the hydromineral regulation.

These alterations probably have partly a cellular base. Certain metals, such as cadmium, copper, mercury, lead, can also interfere by combining with the cellular membrane. As the osmoregulatory capacity in fish and invertebrates, varies with temperature, thermal pollution may interfere with the osmoregulation and ionic regulation of marine animals. This is of particularly great practical importance in tropical regions.

The osmo- and ionic regulatory processes are also of prime importance in the triggering and the development of migratory phenomena. The inherited gradual modifications of osmoregulatory mechanisms during the life cycle may be an essential factor in this connection. Disturbances of these mechanisms may bring about developmental malfunctions, as well as important modifications of migratory behaviour, and even death.

It was considered of great interest, therefore, to study the effects of pollutants on the osmoregulatory mechanisms of different marine species. On the other hand, modifications of osmoregulation, either as a function of a change of the natural environment (for example, salinity change), or under the action of a given pollutant, will have an effect on absorption and excretion of other pollutants. Finally, the effects of changes in chemical composition of the environment on a homeo-osmotic marine animal may provide a basis for a suitable sublethal test.

(iv) Effects on reproduction, development and growth

A number of examples were given of the effect of various pollutants on those physiological functions which are particularly vulnerable to modifications of environmental conditions. Heat discharge, although it sometimes has advantageous effects on the establishment or the culture of certain resources in specific areas, was considered in most cases to be deleterious. It particularly adversely affects the processes of maturation and fertilization, as well as the survival of eggs and larvae, in the latter case the effect being either direct or indirect, e.g., through the inhibition of feeding. Changes in salinity, turbidity as well as reduced dissolved oxygen concentration of the water, resulting from pollution, can also be harmful to the reproductive functions of marine organisms.

Fish eggs and advanced yolk-sac larvae of fishes, especially at the beginning of feeding, were shown to be particularly sensitive to insecticides and to oil combined with detergents. Pesticides were also reported to prevent the hatching of oyster and mussel eggs. Larval development of molluscs was found to be seriously affected by a number of pesticides. Degenerative changes in testes of crabs were observed as a result of the combined effect of oils and detergents.

In birds, numerous observations have shown the disastrous effect of pesticides on reproduction, which can be explained on the basis of the concentrations of these subs-

tances in higher trophic levels. The reproduction of sea birds is reduced in proportion to the amount of pesticides in the parents and in the eggs. One of the most striking effects on the eggs is the thinning of the shell.

Observations on the inhibition of the settling mechanism in oyster larvae in a culture, otherwise completely normal and where no pollutant could be traced chemically, suggest that such low doses in some substances can affect specific stages of larval development which could not be detected by available chemical means.

(v) Effects on neuro-muscular system and behaviour

A number of substances were reported to have an effect on the nervous system and on the behaviour of marine organisms. Thus, organo-phosphate pesticides inhibit the acetylcholin-esterase activity in the brain of freshwater fish. Oils may inhibit the development of the byssus in mussels, probably through a narcotic action on the muscular activity of the foot or by affecting the secretion of byssus-collagen. With regard to methodological aspects, a technique was referred to for measurement of the action potential within the lateral nerve of fish, which would allow the detection of the neurotoxic action of a pollutant. Ionizing radiation may modify the behaviour of certain aquatic organisms. Zinc affects the migration patterns of salmon. Numerous chemical substances alter the schooling behaviour of some fish.

The ability of animals (generally those with well developed olfactory sense) to detect toxic substances appears to be of special importance, as it may lead to flight reactions. Although these reactions protect the organisms from harm by the pollutant, they may in turn affect their nutritional and reproductive behaviour. Some given examples, however, showed that this ability of some animals by no means applies to all toxic substances. Thus, certain fish capable of avoiding acids and sulphides seem to be attracted to other toxic substances, such as copper, sulphates and ammonia. Some invertebrates (Crangon crangon) can detect and avoid oil dispersants at low concentrations, but when non-aromatic solvents are used together with the dispersants, the ability of detection is reduced.

The effects of pollutants on the mechanisms of secretion, up-take and retention of ectocrine substances were considered to be of particular interest. It was suggested that this problem should be the object of some sublethal tests.

(vi) Effects on cellular physiology

Recent observations have shown that the degree of resistance of various organisms to certain pollutants is closely correlated with the resistance of their tissues. It was considered essential, in order to understand the

action of pollutants, to utilize the resources of biochemistry and biophysics and to apply them to the tissues and cells.

The influence of pollutants on the endocrine and enzymatic systems of marine organisms was illustrated by several examples. Such action can be stimulating, as was shown by the effects of sublethal doses of hydrocarbons on the glycogenesis in mussels (Mercenaria mercenaria); by the effect of chlorinated hydrocarbon pesticides on birds, which may cause the induction of hepatic enzymes that metabolize steroids, and by the drop in the glycogen level within the liver caused by kerosene. On the other hand, inhibiting action occurs, as exemplified by methylparathion on the esterease activity in the blood serum. The presence of pesticides may also result in considerable changes of biochemical characteristics of certain organs, e.g., of the liver of some fish Sphaeroides maculatus. Varied and extensive alterations of cellular activities were reported in oysters (Ostrea gigas) subjected to waste waters from pulp and paper mills, and in this connection, a reduction of the quantity of RNA in the cells and a decrease of calcium absorption were especially pointed out. Differences in toxicity of pesticides on different species of fish could be explained by specific differences in the enzymatic activities which catabolize such compounds.

The potential risks of cancer induction by several types of pollutants (such as the polynuclear aromatic compounds entering the marine environment with oil) and by biosynthesis (probably by anaerobic bacteria) of carcinogenic substances were discussed. It appears that this risk cannot be clearly and quantitatively determined, as we do not have any information on critical thresholds of action of these substances.

It was considered that present development of techniques for culturing tissues of marine fish will provide a possible means of gaining a deeper insight into the mechanism of action of pollutants. The more refined the techniques for studying sublethal effects become, the more the experimental conditions must be accurately kept under control. This would include the important aspects of chronotoxicology.

7.3.3.4 Biological effects of pollution in the natural environment

The need for better complementary programmes, including laboratory tests and studies in the natural environment was especially emphasized. The discussion concentrated around the complex interactions of abiotic and biotic variables and their effects on the responses of marine organisms to poisonous substances in a natural environment. These interactions render predictions of their effects difficult. The properties of many of these variables are still not well understood, and it was considered necessary to gain a better knowledge of the multiparametric responses occurring in natural conditions, in order to correctly assess the ecological effect of

different types of pollution. The need for ecological toxicology was expressed, meaning by this, the toxicology of an ecological system which might be closely reproduced under experimental laboratory conditions. On the other hand, attempts have been made already to determine the specific susceptibility levels of some marine invertebrates, namely polychaetes, to certain types of pollutant. Suggestions were made to consider the establishment of a biological test scale for marine waters, comparable to the saprobial system presently used in fresh waters. In this connection, the intensification of ecological studies in unpolluted waters, especially on benthic communities, appears to be of prime importance.

The development of a satisfactory methodology for the study of the effects of pollutants on organisms in the natural marine environment appears to be still in a rather preliminary stage. However, the development of some new interesting techniques was reported, such as for example, the use in the U.K. of transducers attached to molluscs under natural circumstances, which made it possible to measure certain physiological functions like the cardiac rhythm. These results were correlated with those obtained in the laboratory. Another reported technique was the exposure of benthic invertebrates (polychaetes) in cages to pollution in the surroundings of outlets of waste effluents.

Finally, the side effects of some types of pollution were considered. For example, the danger was noted of proliferation of certain pathogenic bacteria, which might affect schools of commercially important fish, often tending to concentrate around outfalls discharging certain types of organic wastes. The correlation between the release of certain wastes and fish diseases reported for some areas could be explained partly by deterioration of the physiological condition of the fish, as a result of the direct action of a pollutant.

7.3.4 Conclusions and recommendations

The Conference recommended that:

7.3.4.1 An expert panel representative of regions and disciplines be established by FAO, in consultation with GESAMP, to investigate the possibility of standardization of laboratory test methods, and to consider criteria for choice of test and indicator organisms.

7.3.4.2 FAO include in its Species Synopsis Series on Aquatic Species and Stocks, relevant information on the effects of pollution on these organisms, and also that FAO expand this series to include information on species, representing different trophic levels, which are recognized to be particularly useful for the study of the effects of pollution, in the field as well as in the laboratory.

7.3.4.3 FAO consider establishing a register and tabulations, by species and pollutants, of data on biological effects of pollutants, giving special attention to the levels of concentration reached in species of special interest, and to sublethal effects and their minimum threshold values.

7.4 Section IV : Ecosystem modifications and effects on marine communities

Convener:	Dr. R.I. Clutter
Rapporteur:	Dr. C.S. Yentsch
Review papers:	R-10, 14, 17, 33
Experience papers:	E-4, 5, 9, 11, 18, 21, 26, 30, 36, 41, 51, 52, 53, 55, 60, 62, 65, 71, 99, 100, 101, 102*
Referred from other sections:	R-1, 5, 6, 9, 26 E-6, 14, 19, 27, 28, 34, 35, 47, 50, 61, 66, 72

7.4.1 Introduction

Man attempts to develop the earth into a more reliable, benign home through simplifying it. The plough prepares a seed bed, but its main effect is to simplify the field by keeping out weeds. Chemical nutrients, herbicides and pesticides further reduce the numbers of kinds of plants and animals. The closer the field approaches monoculture - a single species - the more difficult its maintenance becomes, because it is inherently unstable compared with the natural community that would inhabit the same plot of ground.

Wild species have evolved and diversified over eons, and the living structures of ecosystems have evolved along with them. Taking an extreme view about the "balance of nature", one might argue that the wild systems are so closely integrated and balanced that the growing influence of man must cause their eventual collapse. Some evidence, however, contradicts this. Some intense and poorly controlled agricultural practices have laid lands to waste, but other fields and pastures have been kept healthy with only moderate and unchanging effort for hundreds of years - at least prior to the technological age. And some carefully managed fisheries have produced good catches for many decades.

Apparently the biological system of the earth and the sea can withstand a certain amount of stress from man's activities. The amount of stress that we can impose on these systems depends on how much control we can impose, or how much variability we are willing to accept and how much instability communities can stand without losing their essential structure.

To determine the effects of pollution or other stresses on ecosystems, we must know how they function and how they respond to stress. This involves productivity, diversity, predictability and stability. Agricultural fields have nutrient-rich soil, high productivity, and low diversity. Forests have nutrient-poor soils, low productivity, and high diversity. Fish culture ponds and oceanic waters have the same properties respectively. The richer ocean waters usually support larger and less stable populations of fewer species than the poorer waters do.

Stress on marine communities, including the addition of excess nutrients, tends to lower diversity and therefore decrease stability. Stresses other than nutrients decrease stability without increasing productivity, and their effects are negative only. Whether additional nutrients have positive or negative value to man depends on how much is added,

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* Available as abstract only

how much harvesting variability man is willing to accept, and how high a probability of change in community structure he is willing to gamble on. The word "gamble" seems appropriate here because we cannot control and manage the marine ecosystems as we can our fields.

There is clear evidence that we are gambling at the fringes of the sea. During the session it became clear that, although we know enough already to indicate the need for action, much more in-depth and more long-term research must be done to know how ecosystems operate. Only through this knowledge can the ultimate effects of pollution be predicted.

7.4.2 Themes for discussion

(a) Ecosystem models

(b) Responses to stress

(c) Baseline studies

(d) Monitoring

(e) Concentrations in food chains

Format: (1) community theory - diversity and stability

(2) ecosystems

(i) benthic - nearshore (general)
interstitial
deeper waters

(ii) tropical shallow waters

(iii) pelagic

(3) general discussion

7.4.3 Summary of discussion

7.4.3.1 Ecosystem theory

The use of predictive models to explain spatial or seasonal changes of individual species has been of great interest to ecologists, and is of great potential value for management purposes. Accumulating enough information on physiology and population dynamics to allow a sensible assessment of such changes is for the future. However, ecosystem theory does provide us with a means for analyzing the causes of large-scale phenomena in ecosystems. For work at the community or ecosystem level, we need to emphasize species similarities, grouping some into new ecological supertaxa or other ecologically definable units of a community. This approach was seriously explored by the Conference, with reference to the stress of pollution.

The components of one model include: the Shannon-Wiener diversity index; Margalef's index of stability in the sense of persistence through time of biomass components; measures of the instability of the aquatic medium. Fairly simple models constructed with these components - when placed in the context of what is known about ecological successions, community structure, the dependence of

poikilotherm metabolic rates on temperature, and production - provide a general framework. Apparently, such stresses as fisheries exploitation, toxic waste disposal, dumping of non-toxic organic wastes, and nutrient enrichment produce some similar effects. In particular, a stress alone will reduce the stability and diversity of a community by tending to kill the longer-lived, larger organisms, or, in the case of nutrients, by favouring short-lived opportunists. The variable application of stress and the natural fluctuations of abiotic environmental variables accentuate the stress effects on community instability.

It follows that a polluted aquatic area will be dominated by opportunistic, short-lived, prolific, vagile species that will fluctuate markedly in abundance through time and space. Opportunistic species are commonly less valuable than climax species (e.g. large fish) and sometimes harmful (e.g. red tide organisms). Productivity *per se* is not an index of the stability or success of a community, and is not a good indication of its potential usefulness to man as an exploiter.

7.4.3.2 The marine ecosystems

Because of man's industrial and recreational uses, heretofore untouched ecosystems such as coral reefs, adjacent lagoons and mangrove swamps are in danger. Throughout the tropics of the world, specific cases are recorded of damage by oil spills, sewage, dredging operations and filling. In the ecosystem terminology, most of these tropical ecosystems are characterized by being highly productive and highly diverse; however, in most cases, not enough is known about the biological mechanisms to ascertain the causes or the levels at which pollutants affect (stress) the system to the point of triggering collapse or radical transformation. Some information suggests that mangroves are relatively insensitive to sewage wastes, while small amounts of sewage affect corals severely. Conversely, small amounts of oil seem to have no short-term effects on corals, but oil damages mangroves.

Because of variability in environmental factors, some of these ecosystems have high diversity indices and some have low indices. Estuaries are good examples of low diversity, presumably because of short-term, severe abiotic fluctuations. Available evidence suggests that these ecosystems are unstable; hence, violent changes in population numbers can occur. Man tends to congregate near estuaries and a large amount of evidence of pollution damage is accumulating. Other littoral ecosystems, beaches and sub-littoral, are characterized by high diversity and stability, at least in tropical and semi-tropical environments. It is suspected that most of these will be found to be extremely sensitive to stress.

The pelagic ocean is a stable ecosystem characterized by high diversity, a great deal of specialization among individuals, and low productivity. Because it is the largest ecosystem on earth, its contribution to total productivity on this planet is large. Typical of stable ecosystems, the patterns of energy flowing through trophic levels is complex.

The only available information suggests that deep ocean benthic communities of organisms have high diversity and high stability. Because of the uniformity of the environment and the genetically fixed specialization of the organisms to this uniformity, these populations can be suspected to be extremely sensitive to stress. Productivity of these communities is low. Prior to a few years ago, it was believed that about 1 - 10 percent of the organic material produced in the euphotic zone settled to the bottom and was consumed by the benthic fauna. More recent measurements throughout the water column show that almost all of the organic matter formed in the euphotic zone is decomposed in the upper 200 meters. Speculation as to the mechanism of food supply to deep water organisms includes very rapid settlement of large organic particles, absorption of dissolved organics on inert particles, transfer of shallow water material to deep water by bottom currents, and a successive cycling of organic material by vertically-migrating animals.

In no case do we possess complete knowledge of the flora and fauna of an aquatic community. Over vast areas of the earth even the common, easily obtained forms are poorly known, resulting in a continued need for the descriptive phase of biology. Taxonomic identification of species in communities, and as indicator and test organisms, should be subjected to similar standards of exactitude as are applied to the chemical identification of pollutants.

The suitability of the deep oceans as a dump site was discussed. Ecological damage caused by dumping highly toxic pollutants in the deep ocean was considered by constructing a simple analytical model from a set of postulated conditions which were considered to be extreme. Some physical, chemical, and biological factors were taken into account in model construction. The most conservative assumptions regarding water movement were to assume that there was no vertical turbulence nor horizontal transport. The hypothetical site was considered to be a flat region. The toxicant was assumed to spread at a constant rate in a thin film from its source in all directions, penetrating to a uniform depth in the underlying sediments. For a first approximation, the dosage-response curve was assumed to be linear, and the rate of decomposition of the pollutant was assumed to be a linear function of time. Substitution of coefficients into the final working model indicated that the rate of decomposition or detoxication of the material was the most important single factor in

determining ecological damage.On the basis of this work, it was suggested that highly toxic (but short-lived) pollutants were less important than those that persisted for long periods of time from the point of view of damage to organisms.

7.4.4 Concluding remarks by the Convener

The development of ecosystem theory is an efficient approach to understanding community responses to broad stresses and to the level of sensitivity of ecosystems of our earth and, therefore, of great value for measurement of the environment. This is not seen as a substitute for theory at lower levels of organization, e.g. populations and organisms.

Research at all levels of organization is equally important. The discussions emphasized that to understand the ultimate effects of pollution or other stresses on marine ecosystems, comprehensive multidisciplinary studies are imperative. These should include in particular: structures and processes characteristic of coral reefs and lagoons, mangrove associations, neritic and deep-sea benthos, including interstitial fauna and pelagic systems. The effects of stress on communities must be inferred from replicate studies in a number of communities. A series of long-term baseline studies, perhaps somewhat less intensive and detailed, should be included. Only in the context of such studies would monitoring data become meaningful.

7.4.5 Conclusions and recommendations

The Conference recommended that a carefully composed working party of marine ecologists be established by FAO to collaborate with IBP to (1) review the present state of understanding of marine ecosystems with respect to pollution, and (2) prepare a system of priorities and detailed and costed working programmes for future studies on the potential effects of pollution on the ecosystems.

7.5 Section V : Technical aspects of minimizing pollution and countering its effects

Convener:	Dr. S.K. Freyschuss
Rapporteur:	Prof. E.A. Pearson
Review papers:	R-1, 4, 13, 21*, 22, 23, 29*
Experience papers:	E-1, 2, 8, 10, 15, 25, 58, 73, 77, 84, 86, 96, 103, 104, 105
Referred from other sections:	R-1
	E-11, 60, 97

7.5.1 Introduction

Papers available for review in thisSection covered a broad range of topics from reviews of conventional methods of waste treatment to oil pollution and aquaculture. Unfortunately, the paper coverage did not include identification of the major specific pollution problems of concern or the pertinent combinations of waste treatment and dispersal (dilution) systems needed to alleviate the problems. Marine waste disposal problems generally are not of the classical type (i.e. dissolved oxygen - BOD problem) encountered with inland waste disposal; however, all too often traditional inland waste treatment practices have been applied to marine locations. The results of such traditional practices often have not been best suited to the particular location. Thus maximum benefit to the marine environment has not been obtained even though tremendous capital investments have been made for waste

* Available as abstract only

disposal systems. Some of the many reasons for such practices include: (a) a lack of basic information on the physical, chemical and biological characteristics of the nearshore waters; (b) limited data on the significant physical processes that affect such characteristics; (c) a lack of awareness on the part of the planners and engineers as to what information is presently available; and (d) inadequate quantitative descriptions of the role, significance and value of the living resource of concern. It is only by improving communication between planners, engineers and scientists and focussing attention on pollution generally that substantial improvements in waste management practices can be effected.

7.5.2 Themes for discussion

(a) Treatment of effluents

Industrial waste water treatment
Sewage treatment

(b) Waste disposal

By submarine outlets
By dumping

(c) Oil pollution

Effects on marine organisms
Microbiological degradation
Combating accidental release

(d) Instrumentation for monitoring

(e) Aquaculture as a means of minimizing pollution

Thermal aquaculture
Utilization of treated sewage and industrial waste water

7.5.3 Summary of discussion

7.5.3.1 Waste treatment

It was noted that waste water treatment technology is available to meet any desired quality requirements including that for drinking water supply. Generally, the cost of waste water treatment is directly related to effluent quality. Thus, to ensure high quality of effluents, a realistic case must be made for the need for such quality and of the consequences if the desired standards are not met. More attention needs to be given to the control of objectionable pollutants at the source, especially those that are non-degradable, toxic, and of such character that they can be concentrated by several orders of magnitude in marine organisms. The most effective and economic solution to many industrial pollutants is by control at the source (within the plant) through good housekeeping practices, process modification, and product recovery and utilization. It was noted that in a particular plant (unbleached kraft pulping) the total plant discharge of BOD had been reduced by over 85% through in-house process modifications. It must, however, be recognized that it is rarely possible to completely eliminate water discharge by in-house modifications, making some form of external

treatment and waste discharge to the environment unavoidable. This is also true for modern municipal waste management systems where a high degree of waste water reclamation is practised. Here, too, there will be a residual waste stream - the so-called "non-reclaimables" - which is mostly salt, that must receive terminal treatment and discharge to the environment, generally reaching the ocean.

7.5.3.2 Waste disposal

a) By submarine outlets

The theoretical bases for the design of effective open coastal submarine outfall dispersion systems have been verified in both small (< 0.1 m^3/s) and large (> 15 m^3/s) systems. Marine waste dispersion systems having outfall lengths from shore as great as 8 kms, and pipe diameters of 2 to 3 meters discharging at depths of 30 to 80 meters, are capable of initial dilutions of waste with receiving water at the discharge source of at least 1:100 and often in the order of 1:150 or more. It is obvious that dilutions of this magnitude provide a substantial safety factor - equivalent to a high degree of treatment for non-conservative waste constituents in reducing the concentration of pollutants and subsequent effects in the immediate vicinity of the discharge. However, dilution alone is not an adequate disposal solution for materials that are conservative and that can concentrate in the biota, such as mercury and chlorinated hydrocarbons.

Differences in conditions in receiving water, such as deep open coasts with marked density structure (pycnoclines), as compared to shallow embayments and restricted seas without density gradations, require different concepts and mathematical models for the prediction of waste dilutions and concentrations. The proper design of marine waste disposal systems requires detailed consideration of the hydrographic characteristics of the disposal site, the water quality requirements and the optimum combination of treatment and dispersion to produce acceptable and safe waste concentrations in the immediate area of the discharge.

Effluent standards or criteria and receiving water criteria were considered and, while somewhat controversial, there appeared to be a consensus that some type of general receiving water criteria or objectives are needed and should be developed.

b) By dumping

Some concentrated wastes, such as inorganic acid solutions, can be more economically and safely handled by discharge from a moving ship (barge) at a great distance from shore and at considerable depth, rather than by discharge into conventional sewerage systems. Field studies of actual barge operations indicate that waste dilutions of > 100 are attainable at the discharge location in the propellor

stream of a ship moving at about 10 kts and equipped with a well designed and operated discharge system. Dilutions increased rapidly in the wake of the ship, reaching values of >1000 at a distance of 500 meters from the release point.

Studies conducted in areas where containers have been dumped in the ocean, sometimes in significant fishery areas, have indicated lack of integrity and inappropriate buoyancy in containers of such degree as to be a hazard and to cause gross economic loss to fishing operations. Faulty containers have been recovered in trawls - sometimes as many as eight in one haul.

The hazards of deep-ocean dumping of exotic chemicals, including chlorinated hydrocarbons, were reviewed. Chemical "fingerprints" of discharged wastes have been traced over a broad expanse of the Atlantic in the water column and in the biota.

More attention needs to be given to evaluation of the short- and long-term effects of dumping concentrated waste of all types from ships, both with and without containers. Especial attention needs to be given to the conservative and exotic wastes, including chlorinated hydrocarbons and the polychlorinated biphenyls. It must be recognized that waste discharge from moving ships may be acceptable for contaminants that are non-conservative and where toxic concentrations can be eliminated by dilution alone. However, such operations are risky when used for conservative toxic wastes - especially those that can be accumulated or concentrated in the biota by chemical or biological processes. Technology should be developed for the economic destruction of toxic materials without discharge to the sea.

7.5.3.3 Oil Pollution

It has been estimated that the influx of oil to the ocean from shipping and by accidents in ports is at least one million metric tons per year. In addition, oil from drilling accidents and land-based sources, such as municipal and industrial wastes, are substantial in tonnage and nuisance level. The total hydrocarbons discharged annually in the treated waste waters from the city and county of Los Angeles, California, is of the same magnitude as the total oil released during the first year of the ill-famed Santa Barbara Channel oil accident. Similar quantities of hydrocarbons have been discharged each year, likely for decades, in the treated waste waters reaching San Francisco Bay. Considering the quantities involved and the general acceptability of these bodies of water with respect to oil it must be concluded that such hydrocarbons are probably degraded rapidly and not very toxic to the marine biota.

a) Effects on marine organisms

Some participants expressed the opinion that crude oils and fractions thereof are more or less poisonous to all marine organisms. However, only very few data are available so far to show these effects on organisms as a function of the concentration, kinds of oil and the time of exposure of the organism. Such information is needed urgently if optimum progress is to be made in abatement of the oil pollution problem. Claims both about immediate toxic effects and the destructive action of oil and about long-term "low-level" effects must be documented.

Considerable disagreement exists as to whether or not the large-scale oil spills have been as damaging to the biota as has been claimed. Also the question of the significance of the nuisance and aesthetic problems with oil, as compared to the ecological effects, is most controversial. It is alleged by some that countermeasures such as the use of detergents and dispersants - even the so-called "non-toxic" types - are more harmful than if the oil were left to decay naturally. It is claimed that the use of such materials increases the rate of absorption of the entire oil mass into the marine organisms. There is a wide difference of opinion and need for additional study on the role and effects of dispersants in cleaning up oil spills.

b) Microbiological degradation

Microbiological degradation of hydrocarbons is well known; the oil concentration limits within which such degradation can occur are not. The conditions for optimum rates of oil degradation, as well as kinetic descriptions (rate constants), are not known. Much work is needed to asses the toxic-time-concentration function and the degradation kinetics so that proper control measures can be instituted to minimize the effects of oil pollution. Preliminary research indicates that it may be possible to increase the rate of in situ degradation of oils by the "seeding" of the oil slicks with oil-utilizing strains of yeasts (such as Candida spp); however, it was noted that it may be necessary to add nutrients (such as N and P) and essential co-factors. The field application of such methods requires much additional study.

c) Combating accidental releases

Much work is underway on various methods to combat accidental spills. However, the success of the various methods used, as reported by different investigations, has been highly variable. It is apparent that this, too, is a subject needing much additional research and evaluation.

7.5.3.4 Instrumentation and monitoring

Only by substantial field use of available instruments and methods can the problem of accurate routine monitoring at expected pollution levels be solved. Development

of instrumentation for continuous recording of chemical quality parameters is in its infancy, and the recording of biological parameters scarcely has been considered. Environmental monitoring efforts, particularly with respect to land-based waste input and ocean and, possibly atmosphere, should be coordinated.

7.5.3.5 Aquaculture

There are many examples of the utilization of the organic and nutrient content of domestic, and even of some industrial wastes, for the production of edible fish and shellfish. More attention should be given to the utilization of waste materials and waste heat, for accelerated food production in both developing and developed countries. Average yields of commercially important fish of 147 kg/ha in the sewage-enriched Lake of Tunis is one good example of such utilization. Problems include aesthetic considerations as well as fish diseases resulting from the restricted and densely populated rearing facilities; it is believed both can be overcome by research and enlightened practices. Considering the rapidly increasing practice of re-using highly purified municipal waste water for all uses including drinking, the aesthetic problem of fish production from wastes should be soluble by education. Aquaculture is an excellent example of a possible benefit from enlightened waste disposal practices - and such benefits may also accrue in the ocean if the treatment and disposal systems are properly designed and operated.

7.5.4 Concluding remarks by the Convener

One of the most effective ways of reducing waste discharge is by recycling or re-use at the source. In industry this includes process modification and product recovery through good housekeeping practices; in municipal waste systems, it includes control of industrial effluents, separation of storm and cooling water, and treatment and re-use of domestic wastes wherever feasible and economic.

Modern technology is capable of treating municipal waste waters and some industrial wastes to as high a quality level as is required for drinking or any other use, the cost of treatment being generally proportional to the quality level.

Specific and statistically-defined water quality criteria are needed to ensure protection of the marine resources and to provide a basis for planning waste management systems.

Waste management systems include both treatment to remove pollutants, and dispersion (dilution) systems, to reduce the impact of the residual wastes on the marine environment. Dilutions of waste in excess of 100 are possible in most marine waste disposal situations. Dilution can be as good as treatment for non-conservative materials. However, dilution alone is not adequate for materials that

are conservative, toxic, and concentrated in the marine biota. The only solutions for such materials are elimination at the source or treatment to remove a high fraction of the toxic residual materials.

There is inadequate information on the magnitude and effects of oil discharges and on the efficacy of methods to remove oil from waste waters and the environment. There is no doubt, however, that the quantities of oil discharged to the oceans must be markedly reduced.

The increasing practice of ship and barge discharge of exotic chemicals (including the chlorinated hydrocarbons), in both liquid and solid form (containers), should be examined critically in all respects to assess its short- and long-term effects.

There is inadequate information on the magnitude of pollutant discharges to the sea from all significant sources and on the current concentrations of pollutants.

Inadequate quantitative data are available on the present (to say nothing of the future) condition of the marine biota and such data are needed urgently if the technology of waste disposal is to be improved significantly.

The success of limited efforts in aquaculture indicates that one of the effective ways to utilize domestic and selected industrial wastes is to produce, under carefully controlled conditions, marketable food products from the energy and nutrients available in the waste stream. The results obtained in aquaculture are an indication of the possible benefits from carefully controlled waste disposal practices utilizing the ocean as the culture system, i.e. controlled enrichment and increased productivity by well designed systems for waste disposal.

7.5.5 Conclusions and recommendations

The Conference recommended that:

7.5.5.1 FAO, in association with appropriate international and national organizations, should encourage a quantitative world-wide inventory of the pertinent discharges of pollutants from all land-based sources, with particular emphasis on river discharges and waste streams to the seas.

7.5.5.2 FAO and appropriate international and national agencies should be encouraged to identify the major pollutants of concern to the marine environment and the fishery, and document how the deleterious effects are related to the levels of pollutants.

7.5.5.3 FAO and appropriate international and national agencies should work diligently to ensure that all marine waste treatment and disposal systems are designed and operated with respect to particular problems of concern to the marine environment.

7.5.5.4 FAO and appropriate international and national agencies should work actively for the specifications and use of numerical and statistically valid marine water quality parameters and should oppose the use of non-definitive and non-applicable statements about marine water quality or pollution.

7.5.5.5 FAO should cooperate with appropriate agencies in working toward the eventual curtailing of the widespread practice of dumping wastes, especially persistent toxic substances, in the oceans. In the interim one step could be to encourage international studies of existing and selected dumping sites and make a scientific evaluation of both the short-and long-term effects of such practices.

7.5.5.6 FAO and appropriate agencies should call attention to the increasing hazards associated with the entrance of persistent toxic substances into the sea. Because of the tendency of some materials such as chlorinated hydrocarbons (both aliphatic and aromatic) to accumulate in living organisms and the possible biological effects even at very low levels, special studies are needed to assess both the short-and long-term effects.

7.5.5.7 FAO should cooperate with appropriate agencies in bringing about cessation of the practice of dumping toxic wastes, containers of waste, and/or obstacles in present and potential fishing grounds because of the hazard and the economic loss to fishing operations resulting from such actions.

7.5.5.8 Increased attention and support be given to the assessment of the oil pollution problems including accurate evaluation of the major sources and their characteristics, short-and long-term effects at various concentration levels, efficacy of various methods of minimizing the effects of oil spills on the biota, development of methods for routine measurement of oil concentrations and development of improved methods for the oil removal from the marine environment whatever its source.

7.5.5.9 FAO, along with appropriate agencies, should encourage and support the development of instrumentation for continuous monitoring of the pertinent physical, chemical and biological parameters of the ocean to ensure protection of the marine fishery. Continuing world-wide monitoring is needed and should be coordinated with other related monitoring, such as river and pollutant source monitoring. Particular attention needs to be given to the selection of biological parameters suitable for an adequate, statistically valid description of the principal biota.

7.5.5.10 That, because certain countries use sewage effluents for the production of fish, and because of the health implications involved, FAO and WHO, with the assistance of an inter-disciplinary group of experts, should review the problems associated with this activity.

7.6 Section VI : Effects of pollutants on quality of marine products and effects on fishing

Convener: Dr. D. Idler

Rapporteur: Dr. B.W. Halstead

Review papers: R-6, 12

Experience papers: E-24, 27, 28, 38, 39, 42, 47, 74, 78, 87, 90, 106

Referred from other sections: R-1, 14, 16, 20, 26

7.6.1 Introduction

Fisheries can be adversely affected by any pollutant which kills animals or renders products unsalable for any reason. Sublethal effects can be equally serious by interfering with reproduction or in rendering an animal unable to perform and compete in its environment. The subject matter of this section can be divided into three major categories: (1) intoxicants, (2) microbiological contaminants, (3) pollutants that alter the flavour, texture or colour of fisheries products.

Toxic substances commonly encountered in the marine environment and associated with marine pollution fall into two major categories: (a) natural-occurring marine biotoxicants, and (b) industrial intoxicants.

The review and experience papers deal with various aspects as to how these pollutants affect the quality, edibility and marketability of marine fisheries products. Six topics for discussion were selected with the intent of focussing on current problem areas or gaps in our knowledge.

7.6.2 Themes for discussion

(a) Current status and suitability of detection methods for pathogenic microorganisms in marine products and sea water. How effective and practical are cleansing procedures for (a) shellfish, (b) fish?

(b) Can marine protein concentrate provide a means of preparing uncontaminated protein from contaminated resources? What contaminants are worthy of urgent research attention?

(c) What instances of pollution can we cite where direct damage has resulted to fishery resources in Europe, North America, Asia, Africa, tropical islands, Arctic region?

(d) What is the damage to marine resources from oil spills? What procedures should and should not be employed to minimize such damage?

(e) What is the toxicological significance for man of pollutant levels in marine products?

(f) How can scientists work with industry to help minimize industrial pollution of the fishery resource?

7.6.3 Summary of discussion

7.6.3.1 Current status and suitability of microbiological detection methods

Several factors render marine bivalves particularly susceptible to pollution in estuarine and coastal water. These species live close to man's activities and their feeding mechanism results in the extraction and concentration of bacterial and viral pathogens, as well as toxic substances such as pesticides, biotoxins, radionuclides and heavy metals. The most important bacterial pathogens include Salmonella spp., Shigella spp., Vibria spp., and under certain conditions also Clostridia spp. The only documented virus infection appears to be that of infectious hepatitis.

There was reason to question the validity of a single bacteriological test to judge the suitability of shellfish for human consumption, water quality in the growing areas, the use of water for recreational purposes, and the use of water for fish processing. It was generally agreed that the coliform test was insufficient by itself; it needs to be supplemented by an E-Coli test, and where appropriate, by a fecal streptococci test. However, it was noted that salmonella can be present in the absence of coliforms at considerable distances from sewer outlets. Some concern was expressed that bacteriological criteria may not accurately reflect the presence of viral contamination.

Depuration has been demonstrated to be a useful technique for cleansing shellfish of bacterial contamination when the bacterial load is moderate. However, shellfish growing areas must be closed when the bacterial load is heavy, and in this case, the only remedy is complete sewage treatment. No evidence was presented that depuration eliminated viral or chemical contaminants.

7.6.3.2 Marine protein concentrates

It was suggested that if intoxicants such as mercury, hydrocarbons, pesticides, heavy metals, etc., were protein bound, then these poisons would be passed on to man in even higher concentration than normally received by eating fresh fish. It was pointed out that FPC is intended as a protein supplement and that FPC would therefore essentially contain the same amount of the pollutant that might be ingested on a protein-unit basis as a result of eating fresh fish. Moreover, the protein of FPC would probably contain less intoxicants because of the extraction process. Hot, aqueous isopropanol is expected to remove some of the protein-bound pollutants. There was no laboratory evidence, however, to indicate to what extent this would be true in the broad spectrum of intoxicants present in the marine environment. The question was also raised as to whether or not FPC extraction procedures would remove natural-occurring marine biotoxins. It was pointed out

that there are no controlled studies presently available on that aspect of the problem. Although FPC might be used on only a supplementary basis in developed countries, there is the possibility that in developing countries it could conceivably be used on a larger-scale basis, in which case, toxic pollutants even at low levels over an extended period of time might be of concern. It was agreed that further research is needed on the possible contamination of FPC by either marine biotoxins or by toxic industrial pollutants. Fish protein concentrate is expected to provide one means of removing pollutants from man's food.

7.6.3.3 Instances of pollution that have affected fisheries resources

Toxic chemical pollutants are derived from many sources. Although an inefficient industrial technology was recognized as a major contributor, it was also pointed out that domestic sewage and waste from research laboratories, military installations, hospitals, and from a wide variety of governmental operations, agricultural practices, etc., are also significant contributors. In brief, the widespread indiscriminate use of poisons by the public must share in the responsibility for the overall influx of intoxicants into the marine environment.

Included within the general category of industrial intoxicants are such substances as heavy metals and other inorganics, petroleum, petrochemicals and other organics, and pesticides. Many of these materials have been found to be toxic to both marine organisms and man.

a) Natural-occurring marine biotoxins

Although a broad spectrum of marine biotoxins are known to occur in the marine environment, only paralytic shellfish poison, ciguatoxin, clupeotoxin, and possibly tetrotoxins, have been suggested as having a possible relationship to the overall pollution problem. The biogenesis of these biotoxins is presently unknown. However, field observations indicate that contaminants such as various metallic compounds, dumping of war materials, industrial wastes, ship wreckage, etc., may trigger toxicity cycles in marine organisms. The organisms affected include algae, shellfish and vertebrate fishes. Environmental disturbances such as storms, dredging, mining operations, blasting, volcanic eruptions, alterations in salinity, thermal pollution, etc., may cause serious ecological changes and thereby provide an environment conducive to the development of toxic organisms. A correlation has been observed repeatedly between: (1) the availability of new surfaces in the reef environment, (2) the rapid growth of algae, and (3) the development of ciguatoxicity in normally edible species of reef fishes within the immediate vicinity. These problems are especially common in tropical insular areas of the world. The mechanisms involved in the ecological biogenesis of these poisons are unknown. The overall problem of marine biotoxicity in tropical insular areas is deemed to be of great economic importance to the development of fisheries in tropical insular countries.

b) Heavy metals and other inorganics

The inorganics considered as pollutants of the marine environment include the following: aluminium, arsenic, beryllium, fluoride, hydrogen acids, hydrogen sulfide, iron, lead, mercury, phosphorus, selenium, titanium, vanadium, zinc.

All of these substances are toxic to one extent or another. The degree of toxicity in any given amount of the substance varies from one species of organism to the next. These substances are of great public health concern because of their ever-increasing build-up and long-term persistence in the marine environment. In many instances, the portals of entry into the marine environment are unknown. Although mercury and lead are generally considered to be the most threatening pollutants, there are others which in the overall picture may be just as serious but are not readily detected because of their insidious toxic properties.

Heavy metals play a role in colour and possibly in flavour problems; copper was implicated in a green discolouration of oysters and iron in a green discolouration of cod fillets.

c) Petroleum

Oil pollution is primarily the consequence of our dependence upon petroleum-based technology. The rapid advances of technology have resulted in a steady increase in the use of petroleum for power, heating, paving and the production of a vast array of petrochemicals. It is estimated that annually there are about 7,500 oil pollution incidents in the United States alone. The total influx of oil to the ocean through shipping and by accidents in port is estimated to be at least 1 million metric tons per year. This figure does not include major catastrophes in production and at sea, unburned fuel, natural seepage, spent lubricants, and a significant hydrocarbon contribution entering the sea from land-based sources, e.g. municipal wastes etc., and the total hydrocarbon influx may well be substantial in tonnage and nuisance value.

Crude petroleum is a complex mixture of natural products and includes many thousands of different compounds. Although crude oils differ markedly in their physical properties, the basic chemical, biological and toxicological properties of crude oil are quite similar. Petroleum and its hydrocarbons have been found to be remarkably stable in the marine environment. Although hydrocarbons that are dissolved in the water column are eventually destroyed by bacteria, the most toxic compounds are the ones that are the most refractory.

The immediate short-term effects of oil pollution are rather obvious. However, some of the most serious aspects of oil pollution deal with the low-level, long-term toxic effects, particularly on young forms of marine animals. The great complexity of the marine food chain and the

stability of the hydrocarbons in marine organisms present a potentially dangerous situation which may adversely affect our fisheries resources. Hydrocarbons may not only be retained, but they may also be concentrated and become protein bound. Thus petroleum may contribute to the destruction of food values through the incorporation of oil and oil products into fisheries resources.

Reference was made to some of the recent activities of the Intergovernmental Maritime Consultative Organization (IMCO), concerned with efforts to minimize the discharge of oil from cargo vessels. Instances were cited where petroleum wastes were giving rise to odour and flavour problems in species which fed on contaminated marine organisms. Considerable concern was expressed about the carcinogenic nature of many hydrocarbons and other substances going into the environment. The serious socio-economic implications and effects on fishing of a recent spill of Bunker C oil in Canada were mentioned.

d) Petrochemicals and other organics

The production of chemicals derived from petroleum has become a highly diversified industry involving thousands of substances. At present, the chemical literature describes more than one million organic compounds, and this number is small when compared to the structural variations possible within even a few classes of organic compounds. Organic pollutants are characterized by their complexity. Petrochemical wastes include both inorganic and organic products. Some polynuclear aromatic hydrocarbon substances have been shown to be some of the most potent environmental carcinogens to test animals, and may probably be so also to others. All organic compounds which are presently entering the marine environment as a result of technological activity may be classified as potential pollutants. Some of these compounds have been demonstrated to have deleterious effects on marine organisms, but the bulk of them have not. The task remains to test the toxicity of these additives and to develop suitable analytical methods for their isolation, detection and determination, as well as their identification in sea water.

e) Pesticides

An enormous number of man-made synthetic economic pesticides have been released into the marine environment. There are over 45,000 registered pesticidal formulations within the United States alone. These highly toxic substances have been released in such large quantities and so broadly that they are among the most widely distributed chemicals on this planet. Pesticides are sold and used primarily for specific purposes and they have the ability to exert biological effects on all living organisms. In addition to their toxic characteristics, some of these compounds have also displayed carcinogenic properties. Pesticides have become of increasing concern to public health workers because of their uncontrolled ubiquitous distribution

which now extends beyond their intended use. Probably the chief known hazard from residues of chlorinated hydrocarbon pesticides in the ocean is their ability to be concentrated by marine organisms. It is apparent that man is disturbing the delicate ecological balance of the marine ecosystem with some highly toxic substances having long-term residual properties, which are now entering the food web of marine organisms and man on a grand scale.

Numerous examples were cited where toxic chemical wastes had seriously damaged coastal and estuarine fisheries. This damage was due to pollution by heavy metals, pesticides, petroleum, petrochemicals, etc. Extensive shellfish grounds have been closed in Canada, the United States, Spain, France, Germany, Japan and elsewhere because of chemical pollution. It is anticipated that additional shellfish grounds will be closed within the near future if the present rate of chemical pollution continues. It is estimated that about 25 percent of the total shellfish grounds of North America have been closed because of pollution.

Excessive levels of mercury have been found in fish in North America, Sweden, Japan, Spain and elsewhere, which has resulted in the unsalability of the fish. Excessive levels of lead, copper, and pesticidal residues have also been reported. Some of these high residues are now being found in pelagic fish species such as mackerel and tuna.

The impact of pollution in fisheries has not only resulted in a loss of many millions of dollars to fisheries, but has also produced serious social problems in some areas such as unemployment and a need to re-educate fishermen in other lines of endeavour.

7.6.3.4 Toxicological significance of pollutants

Industrial pollutants consisting of heavy metals and other inorganics, petroleum, petrochemicals and other organics, and a vast spectrum of pesticides are entering the marine environment on a massive scale. Most of these substances have varying degrees of toxicity to both marine organisms and man. Most have great public health importance and constitute a serious threat to the future utilization of fisheries resources. These poisons pose special problems in environmental toxicology because of their extreme persistence and bio-accumulation. Many of these materials are highly lipophilic and are not adversely affected by water. Some become protein bound within the body of marine organisms and thus enter the food web at all trophic levels including that of man.

Evidence of the toxicity of these industrial pollutants is now observed in the marine environment by the steady increase in cancerous growths, leukemia, skin ulceration, tail deformities, genetic changes, and other disease conditions in fish and shellfish taken from heavily polluted areas in Southern California, Washington, New York, the Baltic Sea, etc. A vast panorama of highly toxic and carcinogenic substances now persist in the marine environment.

Some of the most serious aspects of the overall marine toxicological problems are those of low level, long-term effects. At present, acute toxicity, particularly lethality, is used as the prime indicator of toxicity and pollution. However, acute toxicity is an unreliable standard and a poor indicator of what may actually be taking place within the environment. Therefore, attention must be directed toward the detection of early or relatively low levels of injury. Consideration should also be given to the extrapolation of data on the toxic effects of marine animals and applying them to man.

Permissible levels of intoxicants in the marine environment were discussed. It was pointed out that much of the data are of questionable significance and validity in the light of the long-term persistence and bioaccumulation of intoxicants in the marine environment. There is an almost complete lack of data on the synergistic effects of these poisons on both marine organisms and man.

Research is urgently needed to throw light on the acute and low level chronic effects of intoxicants on a wider range of marine organisms, i.e. plants, invertebrates, and vertebrates.

An ecotoxicological approach is required which will elucidate the synergistic effects of the poisons, and the resulting interactions between plant and animal populations, and their effects on fisheries resources. Studies on the role of pollutants in the biogenesis of marine biotoxins and their effects on fisheries resources, particularly in tropical latitudes, are needed.

It was clearly recognized by many of the participants that there is required a multi-disciplinary approach involving the basic biology, fisheries, chemical, toxicological and health sciences if these problems are to be effectively handled.

7.6.4 Conclusions and recommendations

7.6.4.1 The Conference stressed that research is urgently required to evaluate the efficacy of the processes of making fish protein concentrate for removing pollutants.

7.6.4.2 It was recognized that work is required on the epidemiology of viral contamination and its relationship, where applicable, to bacterial indicators.

7.6.4.3 It was also recognized that investigations are required so that rapid tests may be established which accurately measure pollution with bacterial and viral pathogens.

7.6.4.4 The Conference recommended that studies be conducted to determine the role of pollutants in the biogenesis of marine biotoxins.

7.6.4.5 It was recommended that, as lethality is not a sufficient criterion for reflecting damage to aquatic resources, research should be encouraged to demonstrate (a) sublethal effects which jeopardize survival of populations and/or ecosystems; (b) synergistic effects; and (c) the relationships between levels of pollutants in organisms and toxicity to man.

7.6.4.6 The Conference agreed that much additional research is needed on marine pollution and its effects on living resources and fishing, utilizing a multidisciplinary approach with such disciplines as ecology, fishery biology, oceanography, chemistry, toxicology, and the health sciences.

7.7 Section VII : Scientific basis for international legislative control of marine pollution, in the interests of marine resources and fisheries

Convenor:	Prof. R. Revelle
Rapporteur:	Prof. L.J. Bouchez
Review papers:	R-15, 23, 28
Experience papers:	E-54, 80, 83, 93*
Referred from other sections:	R-3, 5, 16, 18, 20, 21, 25
	E-73, 96, 98

7.7.1 Introduction

Ten propositions concerning pollution of the marine environment deserve consideration:

(i) Pollutants do not respect national boundaries

Like other ocean phenomena, pollutants have no respect for national boundaries, territorial seas, or areas under national jurisdiction. Wherever they originate, pollutants move and spread over the ocean. Although estuaries and inshore waters are commonly the most heavily polluted parts of the sea, poisons, including pesticides, are present everywhere in the high seas.

(ii) Pollution wastes natural resources

Some kinds of marine pollution result in a loss of valuable resources which could be recovered by recycling. For example, most of the phosphates in detergents and excess fertilizers which are carried to oceans in sewage and industrial wastes are permanently lost as a usable resource. This waste will eventually result in higher costs and scarcities of fertilizers for farmers everywhere.

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* Available as an abstract only

(iii) The beneficiaries from pollution should pay the costs

From an economic and social point of view, the problem of pollution is that one group of people benefits directly in monetary terms, at least in the short run, while the costs are imposed on another and usually much larger group of people, and these costs are hard to express completely in monetary terms. This is the classical economic problem of "externalities". One solution is to require the beneficiaries from pollution to pay the costs of repairing the damage. If these costs exceed the benefits, ways to stop polluting will soon be devised.

(iv) The need for effective enforcement of anti-pollution regulations

Present national and international arrangements to control marine pollution are inadequate, because they lack effective means of enforcement. International agreements should include provisions for easily and uniformly applied sanctions which would ensure that the cost to polluters is either greater than the benefits they receive or is sufficient to clean up the pollution and repair the damage.

(v) Shifting the burden of proof

Experience suggests that effective pollution control may depend on shifting the burden of proof from those who could be hurt by pollutants to those who are doing the polluting; that is, the polluters should be made to provide reasonable proof that their activities are harmless.

(vi) Actions must often precede sufficient knowledge

In some problems of pollution and other kinds of environmental damage, it is necessary to act before adequate information and understanding are obtained. This is true whenever there is a likelihood of irreversible changes, or of severe consequence over the short term. The rapid spread of anaerobic conditions in the Baltic Sea due to a combination of oceanographic changes and excessive dumping of industrial wastes, and the presence of poisonous mercury compounds in several kinds of fish, are examples of emergency situations. The direction of future changes is little understood but both situations nevertheless demand urgent action based on admittedly inadequate knowledge.

(vii) More knowledge is needed

Over a longer term, rational and effective pollution control will require much more knowledge than we now possess. Throughout history, the ocean has been the ultimate receptacle of waste products from the land. When does the level of waste products rise to the point where they become pollutants? How and to what extent do pollutants damage human beings and their activities in the ocean, the fish and shellfish needed for human

consumption, the entire ecosystem in a certain part of the sea, or the global ocean ecosystem? And how far and in what ways are these different aspects related to each other?

Comprehensive studies are needed of the physiological and genetic effects of pollutants on marine life and on human beings. We also need to learn what happens to pollutants in the sea - the extent to which they are concentrated in marine plants and animals through the successive steps of the food chain, the nature of the breakdown products (whether they are more or less harmful than the original substances) and the rates of ultimate decay to harmless elements and compounds.

(viii) Technological developments are needed

Pollution problems are sometimes solvable by technological developments. For example, there is a good possibility that new narrow-spectrum pesticides, which are toxic only to certain pests, and are not general poisons, will eliminate the necessity for using DDT within the next few years. New phosphate-free detergents may soon be substituted for the present ones, which contain phosphates that contribute to the eutrophication of lakes and estuaries.

Some pollution processes could actually be turned to beneficial use by suitable technical developments. If waste heat from large electric power plants, which causes thermal pollution when it is disposed of in rivers and estuaries, could be used to warm cold nearshore waters, many beaches might be made much more comfortable for swimming. The ecology would be modified, but not necessarily in a deleterious way.

(ix) Policy makers need more information and better predictions

In order to take rational actions for pollution control, policy makers and the public need more information about the sources and probable consequences of pollution. In particular, they need predictions based on the statistical probabilities that undesirable consequences will occur. Are the chances even one in ten, or one in a million? These statistical probabilities must be balanced by estimates of the benefits and costs of alternative courses of action.

(x) Pollution control requires a change in public attitudes and values

Abatement of pollution, like other actions to maintain and improve the quality of our environment, is costly. The costs must ultimately be borne by the general public, either through higher prices for consumer goods or through taxes, and they will be weighed against the demands for other expenditures. Effective pollution control is thus fundamentally a question of public attitudes and values. These in turn depend on education at all levels, which will instill a better understanding of man's place in nature, a more enlightened concern for long-range goals instead of short-term benefits, and a greater willingness to seek public good rather than private gain.

7.7.2 Themes for discussion

(a) The scientific facts supporting the need for international regulations for pollutants other than oil, nuclear substance and detergents.

(b) Types of pollutants, toxic levels, sublethal effects. Persistence of certain pollutants which have wide effects:

Synergetic effects

Cumulative effects

Different effects of the same pollutant on fresh water and marine organisms.

(c) Points of injection of pollutants, including the atmosphere (sources).

(d) Criteria for the selection of disposal areas, particularly for dumping. Testing of containers.

(e) Scientific basis for pollution control. Prevention and enforcement. The needs for monitoring control and registration.

(f) Evaluation of the effects of measures taken to combat pollution of the marine environment (e.g. detergents, etc.)

(g) Definition of integrated ecological areas for the purpose of international management and control of pollution (e.g. semi-enclosed seas, arctic region, etc.).

(h) The technical and scientific possibilities of establishing a causal link between pollutants and damage to fisheries and the marine environment.

7.7.3 Summary of discussion

International regulations for other pollutants, besides oil and nuclear substances, must be devised, particularly for those types of pollutants which are of high toxicity and are especially persistent. The Conference singled out mercury and persistent pesticides among pollutants requiring special attention.

As far as DDT and related pesticides were concerned, many participants favoured an outright ban, at least as soon as effective narrow-spectrum substitutes become available. Also the development of resistance by insect species, and the fact that predator species important for control often are destroyed by presently used pesticides, suggest the adoption of other means of pest control. Some participants from developing countries felt that in the absence of inexpensive substitutes, they would have to continue, at least for the time being, using DDT and related pesticides.

On mercury pollution, the relatively high concentration in the environment, as well as the lack of data on the sources, concentrations, and sinks in many areas that are likely to be affected, were noted. Special care had to be taken not to add further to mercury pollution. Some participants favoured an outright ban, although regulations would have to be introduced carefully to mitigate the impact on the large segments of industry dependent on its use. Much could be achieved by improving plant technology. Avoidance of mercury pollution is relatively simple and not expensive, especially for new plant installations.

The Conference felt more emphasis should be placed on the overall impact of pollution on the environment because of the interrelation of atmospheric and aquatic processes. As far as atmospheric pollution is concerned, its impact on the marine environment has not yet been scientifically determined, though it is known that several pollutants are carried in the atmosphere to the sea.

Factors influencing the selection of waste disposal areas include the type of pollutant (degree of toxicity and persistence), bottom topography, the type of containers and depth of water.

The criteria for the selection of disposal areas in marine waters must be provided to the policy makers by marine biologists on the basis of knowledge concerning evaluating the possible effects in each specific situation on the living resources and the marine ecosystem.

Effective control of pollution will involve the setting up of maximum permissible levels for pollutants, concentration in effluents, provisions for registering of dumping activities, monitoring levels of pollutants in the waters and in marine organisms and setting up of an efficient institutional framework for the anti-pollution fight. As a guide to industries, the drawing up and dissemination of principles for prevention of pollution from specific causes can be recommended.

The effectiveness of pollution control measures and the time lag in making them operational depends, inter alia, on administrative feasibility and cost factors. Ecological areas for the purpose of international management and control of pollution should be established, in the first place, with regard to fish stocks and local ocean currents. To become politically acceptable, economic and social factors also have to be considered in regional arrangements.

There are several documented examples demonstrating the causal link between pollutants and damage to fisheries and the marine environment. In many cases, however, it is difficult to assess the amount of damage or to establish the source responsible for the damaging pollutants.

7.7.4 Concluding remarks by the Convener

Some international measures are now taken to control the pollution of the sea by oil and radioactive substances. Measures should also be taken against the continued introduction into the marine environment of certain other pollutants such as chlorinated hydrocarbons and mercury on account of their high toxicity and persistency.

Pollutants carried in the atmosphere contribute to marine pollution, but it is not known to what extent.

Regional integrated areas can be defined by using ecological criteria such as the distribution of fish stocks and the systems of ocean currents; and the recognition of such areas should form an initial step towards international control of marine pollution.

Policy makers require further information on the criteria for establishing regulations for the protection of resources threatened by dumping of waste materials into the ocean.

7.7.5 Conclusions and recommendations

The Conference recommended that:

7.7.5.1 Studies should be undertaken to identify integrated ecological regions with the view to future promotion of regional marine pollution control agreements. At the same time it is recognized that the close interrelation between pollution of inland, coastal, and open ocean waters and of the atmosphere calls for one comprehensive system of control covering pollution in all its aspects,

a system in which fishery interests should be adequately represented, and such a system should be sought for urgently.

7.7.5.2 Further studies should be undertaken, with a view to classifying pollutants into categories according to their degree of toxicity and persistency.

7.7.5.3 A working group of lawyers, marine scientists and other concerned specialists should be set up to consider means for the regulation of the introduction into the marine environment of the most toxic and/or highly persistent pollutants. This consideration should include a system of registration to be set up on an urgent basis to cover the dumping of all persistent and highly toxic pollutants into the sea.

7.7.5.4 FAO, in cooperation with WHO and other appropriate international agencies, should intensify its promotion of scientific research to make available pesticides with a narrow spectrum and to develop biological techniques of pest control.

7.7.5.5 FAO, in collaboration with other appropriate international organizations, should establish a programme for the promotion of continuing consultation between lawyers, marine scientists and other specialists concerned with all aspects of marine pollution control in relation to living marine resources.

8 CLOSING CEREMONY

The Chairman, Dr. A.W.H. Needler, gave the closing address. He emphasized that it had been most useful to have present at the Conference experts from so many countries and disciplines. There had been a fertile exchange of ideas, and topics had been discussed from a variety of attitudes and viewpoints.

The Chairman noted that there had been many cases of pollution in coastal waters serious enough to affect fisheries and endanger human health. There are few, if any, cases of such critical pollution in the open ocean but the levels of toxic materials are increasing and unless action is taken they will give reason for very serious concern in the future.

The Chairman stated that there had been a balance at the Conference between the conservative scientific attitude and that of those convinced that action must at times be taken before the firm scientific truth has been established.

The Conference had made a number of recommendations to international and private agencies and to governments to abate or prevent marine pollution. The continuing pollution crisis will ensure that public opinion and the concern of governments will continue to provide wide support to those who must deal with pollution problems. The Chairman noted that great perseverance will be needed to carry out the research, planning and coordination that is necessary if the recommendations of the Conference are to be realized.

The Chairman thanked the Conveners, Rapporteurs and Vice-Chairmen for their valuable contributions and the Secretariat for their work in making the Conference a success.

Dr. Cole thanked Dr. Needler for his excellent performance as Chairman, and the other Conference officials who contributed so valuably.

Mr. Roy I. Jackson officially closed the Conference and expressed the appreciation of the Organization to the Officers and participants for the valuable advice given in the important fields considered by the Conference. He assured that FAO will take them into account in the Organization's future Programme of Work and activities, particularly those concerning field programmes.

APPENDICES

Appendix 1

TIME-TABLE OF THE CONFERENCE

Wednesday, 9 December		
08:30 - 10:00	Registration	
10:00 - 11:00	Opening Ceremony	
11:30 - 13:00	Section I	Marine pollution in the world today
15:00 - 18:00	Section I	(continued)
18:30 - 20:30	Reception at FAO Headquarters	
Thursday, 10 December		
09:30 - 13:00	Section II	Behaviour and fate of pollutants in the marine environment
15:00 - 18:00	Section II	(continued)
18:00 - 20:00	Film Show	
Friday, 11 December		
09:30 - 13:00	Section III	Effects of pollutants on the biology and life cycle of marine organisms
15:00 - 18:00	Section III	(continued)
Saturday, 12 December		
09:30 - 11:00	Section III	Effects of pollutants on the biology and life cycle of marine organisms (continued)
11:30 - 13:30	Plenary Session 1	Discussion of the report of the Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment and of draft report of Section I

Monday, 14 December		
09:30 - 13:00	Section IV	Ecosystem modifications and effects on marine communities
15:00 - 18:00	Section IV	(continued)
Tuesday, 15 December		
09:30 - 13:00	Section V	Technical aspects of minimizing pollution and countering its effects
15:00 - 18:00	Section V	(continued)
18:00 - 20:00	Film Show	
Wednesday, 16 December		
09:30 - 13:00	Section VI	Effects of pollutants on quality of marine products and effects on fishing
15:00 - 16:00	Section VI	(continued)
16:30 - 18:00	Plenary Session 2	Discussion of draft reports of Sections II, III and IV
Thursday, 17 December		
09:30 - 13:00	Plenary Session 3	Discussion of general conclusions
15:00 - 18:30	Section VII	Scientific basis for international legislative control of marine pollution, in the interests of protection of marine resources and fisheries
Friday, 18 December		
10:30 - 12:30	Plenary Session 4	Discussion of draft reports of Sections V, VI and VII, and of final conclusions of the Conference
14:30 - 16:30	Plenary Session 4	(continued)
17:00 - 18:00	Closing Ceremony	

Appendix 2

OFFICERS OF THE CONFERENCE AND THE SECRETARIAT

Chairman	Dr. A.W.H. Needler
Vice-Chairmen	Mr. H. Arafa Dr. G. Meseck Dr. R. Prasad Sr. D.F. Valdez Samudio
General Rapporteur	Dr. M. Waldichuk

Section		Conveners	Rapporteurs
I	Marine pollution in the world today	Dr. H.A. Cole	Mr. A.J. Gilmour
II	Behaviour and fate of pollutants in the marine environment	Dr. J. Joseph	Dr. J.E. Portmann
III	Effects of pollutants on the biology and life cycle of marine organisms	Prof. M. Fontaine	Dr. L. Hannerz
IV	Ecosystem modifications and effects on marine communities	Dr. R. Clutter	Dr. C.S. Yentsch
V	Technical aspects of minimizing pollution and countering its effects	Dr. S.K. Freyschuss	Prof. E.A. Pearson
VI	Effects of pollutants on quality of marine products and effects on fishing	Dr. D.R. Idler	Dr. B.W. Halstead
VII	Scientific basis for international legislative control of marine pollution in the interests of protection of marine resources and fisheries	Prof. R. Revelle	Prof. L.J. Bouchez

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Assistant Secretaries	Dr. D. Sahrhage Dr. G. Tomczak Dr. L. Andrén
Technical Officers	Dr. W. Fischer Mr. R. Marak
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Press and Technical Liaison Officer	Dr. L. Andrén
Scientific Films and Visual Aids Officer	Mr. M. Mistakidis

Secretariat (continued)	
Administrative Officer	Miss M.C. de Freitas
Chief Interpreter	Mr. F. Piraud
Interpreters	Mr. J. Arcocha Mrs. J. Bogianckino Mrs. M. Civelli Miss U. Fusch Mrs. L. Kerr Miss R. Posewitz Mr. J. Terrasa Mrs. C. Tolnay Mrs. G. Whyte

Appendix 3

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Appendix 4

ADDRESS AT THE OPENING CEREMONY

by

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It is with great pleasure that I welcome the participants in the Marine Pollution Conference on behalf of the Director-General of FAO and personally on behalf of the Department of Fisheries. It gives us much satisfaction to provide a forum where such an impressive gathering of world experts can examine the problems of pollution of the sea and the effects on living resources and fishing. It seems to me that in the matter of pollution of the environment we have come to a moment in human affairs where we can and indeed must undertake a rapid and successful revolution against pollution. The scientists of the world have long been aware and studied the threat of pollution. This threat is now recognized by vast numbers of people in most societies and is felt not only at times of major disasters but on a day to day basis. The world assembly at the United Nations is ready and preparing to act. I believe it is therefore most appropriate and timely for FAO to have convened this Conference at the instigation of its member states, the Advisory Committee on Marine Resources Research, and its Committee on Fisheries.

The living resources of the sea are not limitless but they are rich. The world's production of fish has almost doubled in the last decade. This rate of increase is unparalleled by that for any other basic food commodity. The future outlook is moreover encouraging, considering that according to the Indicative World Plan estimates, the world marine fish catch of currently exploited species with known techniques and in already fished areas may amount to some 120 million tons by 1985. Higher estimates are possible by envisaging aquaculture and the utilization of unconventional resources. But it should be realized that not only any increase in catch but the acceptability of the present catch depends on a healthy marine environment. Aquatic environments, communities of living organisms and species, once lost, are non-renewable resources.

The state of the marine environment reflects not only man's uses of the sea but his activities on land. The growth of these uses and activities is a function of the world popu-

lation growth and technological advances. It is not often, if ever, suggested that technological advances be arrested to preserve the environment. The effects of population growth are however repeatedly held up as the root of all the evils we have to contend with. While I share the view that it is imperative for population growth to be reduced to levels we are better able to cope with, I believe that there is little prospect of witnessing the results of any population control measure within some decades. We have therefore to accept a consumption of resources which tends to increase exponentially in relation to population growth, with the industrial development entailed and the resulting effects on the environment. Some of us at times indulge in believing that if industrial development were restricted the environment could be salvaged. I call this no more than wishful thinking.

I would suggest our remedy lies rather in ensuring that economic costs are measured not merely in terms of the direct inputs and immediate products but in terms of those other costs which have been ignored because it has not been easy to quantify them, and in terms of social effects.

We at FAO are particularly concerned with the problem of conflicting uses because of our dual role of promoting development and at the same time attending to the management of the environment and its renewable resources. There are risks of incompatability between these two responsibilities, especially when promoting technical assistance to developing countries. They need to develop their capabilities as rapidly as possible, but it is important that they be spared the mistakes and harmful effects of irrational and mis-costed development. It is irrational to suggest that industrial development in these countries be checked because they often lack the means to cope with harmful side-effects. We believe that by using an ecological approach it is possible to promote agricultural and industrial development without unduly affecting the quality of the environment.

Some pollution problems that are closely connected with particular ecological conditions are best handled at the national or regional level. Local situations can require special solutions developed from local studies. Aquaculture is expected to develop increasingly in coastal areas and is particularly vulnerable to pollution. Since environmental management must accompany application, research is as important in local as well as general development processes.

Many marine environment problems require a global approach. At present the most practical way to attack some of these global problems is through strengthening and efficient coordination of regional or specialized (e.g. marine monitoring) systems. Experience will show whether other new mechanisms should be developed progressively.

To constrain pollution and manage the marine environment will require a large international effort. It will require sentinels and guardians, and a foundation of information on present conditions, and on trends of change. Although we must work quickly, we cannot forbear intensive scientific research and it must encompass a wide scope of ecological investigations including chemistry, physical oceanography, maritime meteorology and many facets of biology.

Marine pollution problems are of common concern to many nations and to various UN organizations. FAO's interest goes back many years. In a review issued in 1959 we recognized our duty to deal with: (a) harm to the living resources on which fisheries are based; (b) interference with fishing gear and operations; (c) harm to consumers from contaminated fishery products; and (d) adverse effects on markets of actual or feared reduction in quality of products.

The so-called Ponza Report on "Global Ocean Research" emphasized the urgent need to develop a marine pollution monitoring system, including a regular report on the "state of health of the oceans". We concur with this. The Seminar on Methods of Detection, Measurement and Monitoring of Pollutants, organized by FAO with the support of some of our sister agencies in the UN system, has just finished. I understand it has done an excellent evaluation of the state of knowledge in analytical methods and technology and has set out the basic requirements for the proposed monitoring system to be considered by your Conference.

We believe that some of these environmental matters can be dealt with through existing organizations that already have the expertise and facilities to provide assistance for various requirements of member countries in these fields. We have therefore adopted the policy of working closely with the other specialized agencies in the UN family and with the many concerned non-governmental organizations. Together we support the Intergovernmental Oceanographic Commission (IOC). Through our support we expect to call on the Commission to promote some of the research of interest to fisheries. We also hope that the Integrated Global Ocean Stations System (IGOSS) now being developed will not only contribute to a fishery forecast system, which our industries and scientists badly need, but will also implement some elements of the proposed ocean pollution monitoring system.

Some years ago FAO proposed the establishment of a Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). It is now in operation, co-sponsored also by five other specialized agencies. It helps to coordinate group actions, and advises on technical and especially interdisciplinary problems. I thank the members of the Group and the other sponsoring organizations for their valuable help in preparing for this Conference. We shall rely on their advice also in implementing the recommendations of this Conference.

Problems of marine pollution will feature more in the future in our technical assistance activities. Developing countries need trained specialists to evaluate marine pollution, to participate in international programmes of interest to them, and to take advantage of technical assistance, which we hope will be promoted through UNDP and through other international sources of funds. We intend to expand training activities. For this reason we made a special effort to help scientists from developing countries to attend this Conference. I acknowledge the Canadian International Development Agency and especially the Swedish and Danish International Development Agencies for their assistance.

You will all be aware of a UN Conference on Problems of the Human Environment that is to be convened in Stockholm in 1972. During a recent meeting with the UN Under-Secretary in charge of that Conference, our Director-General assured him of FAO support. At the same time he indicated a willingness to consider the needs for possible new mechanisms within the UN system to watch over the human environment and he emphasized that such mechanisms should not be involved in operational activities and should supplement but not duplicate existing organizations.

I am sure there will be many national initiatives for international agreement leading to a convention on pollution control. Present trends indicate that control can be accomplished. For example, the President of the United States of America recently defined a policy to ban uncontrolled ocean dumping and to strictly limit ocean disposal of materials harmful to the marine environment. We hope that besides working out broad scale preventive procedures the Human Environment Conference will consider the creation of emergency assistance units to deal with the more likely kinds of pollution catastrophes. These could be similar to the National Disaster Units envisaged within the UN framework to deal with other catastrophes.

From our understanding of the history of the earth and the workings of geophysical processes we know that catastrophes have and will continue to occur. We have to accept unavoidable catastrophes - whether earthquakes or ice ages - and prepare to mitigate their effects when they occur. But we must not accept the apparent inevitability of the avoidable catastrophes that we would bring upon ourselves. The results of this Conference will be valuable as guidance for FAO activities in the marine environment and as background for the Conference on Human Environment. In a larger sense, you are contributing to mankind's resolution to survive.

I thank all of you for your cooperation, and I wish you a successful meeting.

Appendix 5

SEMINAR ON METHODS OF DETECTION, MEASUREMENT AND MONITORING OF POLLUTANTS IN THE MARINE ENVIRONMENT

(Organized by FAO with the support of UNESCO, IAEA, SCOR, WMO)

Rome, Italy, 4-10 December 1970

SUMMARY OF THE REPORT

The future consequences of society's debauchery of the environment are viewed in a variety of ways. The so-called "Jeremiahs of science" predict in the public press and over radio and television, on the basis of losses of natural resources and the mass mortalities of living creatures, the extinction of the human race. Other scientists show little concern for environmental alterations and insist that the powers of technology can overcome any inconveniences resulting from the dispersions of man's wastes. In addition, some of the younger generation have lost respect for social systems that do not provide prompt and decisive countermeasures to environmental insults.

Yet, those in public office, responsible for the management of our surroundings, do rely upon specialists from the scientific community to define critical environmental problems and to provide alternate courses of action to minimize the deleterious effects of man's impingements. It was to this end that FAO assembled (with the support of Unesco, IAEA, SCOR and WMO) during the first week of December 1970 40 of the world's distinguished environmental and natural scientists to identify materials posing threats to the marine environment and to critically appraise the existing methods for their detection, measurement and monitoring. Further, research needs for developing and improving analytical techniques were to be delineated.

The participants were distributed into nine Panels, seven concerned with various groups of pollutants, one with the use of marine organisms to assess contamination levels and one with the establishment of baseline and monitoring systems. The combined results of the deliberations will provide direction for the training of technical personnel and management involved in marine pollution problems.

The world scientists are now ready to measure the health of the oceans. The assemblage of methods for many of the substances introduced to the seas in substantial quantities by the activities of man offers a springboard for a baseline survey to establish their concen-

trations in the waters, organisms and sediments of the sea. All of the panels emphasized the need for such knowledge. If one couples the proposed 1000 sample baseline programme designed at Williamstown, Massachusetts in 1970 with these techniques, an investigation can be initiated immediately. The results of such a study are absolutely essential, before monitoring programmes, that will follow long-term trends or that will document disaster, are begun.

The Seminar delineated an urgent requirement for the gathering of data on the world production of both organic and inorganic chemicals as a guide to evaluate their potential dangers to the environment. In addition, the knowledge of the paths of consumption and disposition, where known, will substantially aid the assignment of priorities for the development of analytical techniques or for the formulation of survey programmes defining their oceanic dispositions. The Seminar urges the establishment of a Document Centre to handle such information as well as related scientific documentation. Further, a citation index indicating the appearance of man-produced substances in the marine environment could be accommodated in such a system.

The formulation of analytical techniques for pollutants in the marine environment has gone hand in hand with the adoption of regulations controlling their releases to the environment. Substances are identified as being dangerous primarily upon the basis of their possible deleterious effects to man, and acceptable levels in water or in organisms of the sea are established. Subsequently laws or policies controlling the environmental dispersion of these materials evolve.

Such has been the case with the radioactive wastes. As a result of the detonations of nuclear devices and of the prospect for more and more fission reactors, hazards that could arise from the uncontrolled dispersion of nuclear wastes were identified. Acceptable levels for the waters, plants, and animals of the sea were developed on the basis of potential dangers to man through his ingestion of seafoods. As a result, discharges of nuclear wastes have been regulated, and the dumping of high level radioactivities to the oceans has been prohibited. The management of nuclear debris has reached such an effective state that the Panel on Radioactivity submits that in the continued absence of extensive nuclear testing there will most probably be a decrease in the oceanic standing crop of artificial radioactive substances during the forthcoming years even though there will be a marked increase in nuclear reactors.

Analytical techniques for other man's wastes entering the oceans such as the halogenated hydrocarbon pesticides and their residues and mercury hopefully will evolve in similar ways. Regulatory actions restricting either the environmental dissemination of these materials or their levels in food products are gradually being adopted in some countries. The pressures to develop sensitive and reliable methods come about when those responsible for the management of our environment need an objective evaluation of existing or potential perils.

The pattern so far developed for the evolution of analytical techniques places a considerable burden upon the scientific community to rapidly identify those materials that can cause perils to our surroundings. Nearly all of the Panels concerned with contaminants identified specific examples of man's waste products which may be leaking to the environment in substantial quantities and for which as yet there are no analytical techniques available.

The Panels were also aware of the difficulties that will arise from the large number of man-introduced materials that are being accumulated in the living organisms of the sea. Dead birds are found to have high contents of mercury, DDT and its residues, and PCB's. Which of these substances acting alone or in combination, have contributed to the fatalities observed?

The Panel on Halogenated Hydrocarbons emphasized that the analytical methods are rapidly evolving for the increasing number of these synthetic chemicals appearing in the oceans. Gas-liquid chromatography has emerged as the most important technique for their assay. Particular attention must be directed to the elimination of interfering substances which may be introduced with the reagents or laboratory ware. Efforts should be made to determine the possible

presence of polychlorinated napthalenes or their derivatives and of fluorinated and brominated compounds in the marine environment. In addition the Panel considered the need for continuing investigations to quantify the amounts of the polychlorinated biphenyls in materials recovered from the oceans.

The Panel on Petroleum pointed out that oil pollution can now be measured at levels corresponding to the natural hydrocarbon background. Urgently needed, however, are additional studies on the natural hydrocarbon composition of marine organisms to more adequately define the impact of petroleum introduction by man upon the oceans. Gas chromatography is the superior technique with regard to sensitivity, selectivity and universal applicability to petroleum pollution studies. Laboratories entering this area of activity should first establish a capability in gas chromatography. The Panel urged research activities to devise methods for the collection of oil films and of oil polluted waters. Further, they indicated the need for better methods to determine polycyclic aromatic hydrocarbons in waters, sediments and marine organisms. These compounds are of special interest because of their involvement in carcinogenesis in animals and man.

The Panel on Organic Chemicals considered the general problems involved in identifying the synthetic organic chemicals (other than the halogenated hydrocarbons and pesticides) that may be entering the oceanic system. Analysts in general have not yet been able to handle concentrations below the parts per billion levels. For pollutants at such levels enrichments in organisms may provide a way to measure their contents in the waters. The Panel considered the ability of sea slicks and oil films to concentrate organic pollutants and hence emphasized the great need for improved techniques to sample thin organic films at the sea surface. The analysis of natural and synthetic organic materials in sea water has not received the attention it deserves and offers most rewarding avenues for research.

The Panel on Inorganic Chemicals submit mercury and lead as the most threatening pollutants within their category. There are three methods of multi-element analysis: neutron activation, mass spectrometry and emission arc, spark or flame spectrometry that are recommended for sea water assays. Preliminary extraction of haavy metals into pyrollidine diothiocarbamate-hexone solution is most useful for the oftimes necessary concentration before analysis. Mercury methods that are widely used involve colorimetry with dithizone, flameless atomic absorption spectrophotometry and activation analysis. The only method that is both sensitive and reliable for lead is isotope dilution mass spectroscopy. The development of other less expensive and less time-consuming techniques is a first priority research item. The Panel emphasised the need for future research methods for distinguishing between the various forms of elements in sea water and for the automation of reliable techniques.

The Panel on Nutrient Chemicals (including those derived from detergents and agricultural chemicals) concerned themselves with those forms of nitrogen, phosphorus and silicon which are necessary to the growth of marine plants and to phytoplankton in particular. In addition the techniques for such related parameters as dissolved oxygen, hydrogen, sulfide and total organic carbon were critically appraised. The Panel considered that existing techniques for nitrate, total nitrogen and silicate are not entirely adequate and that modifications to improve them are most necessary. Like the other panels, the methods are constantly under study and improvements or new techniques are appearing continually. The Panel suggested that the tasks of devising and evaluating new methods should be assigned to particular research institutes and that funds should be allocated from nations and international sources for this work.

The Panel on Suspended Solids and Turbidity were concerned primarily with pollutants consisting of domestic sewage and waste products from industries. The principal difficulties involve obtaining methods for quantitative determinations and for the differentiation between living and dead components. There are no methods developed as yet to determine only the particles which are introduced by pollution. The important research needs involve the identification of the suspended substances by their physical and chemical natures. The rapid and substantial developments in remote sensing from the air and by *in situ* fluorimeters hopefully will generate much needed activity in defining the extent of pollution by suspended solids.

The Panel on Radioactivity looked into the future to ascertain the potential hazards that may arise from the continued increase in the number of nuclear energy reactors and the fuel processing plants serving them. At present, there do not appear to be any significant problems presented by the noble gases Kr-85 and H-3 (tritium) to the marine environment although much concern has been expressed about them recently. Currently available methods for the detection and measurement of artificial radionuclides are adequate for the control of radioactive waste disposal. Future developments will be in the direction of further automation and of in situ determinations.

The Panel on Monitoring Organisms defined the characteristics that govern their selection; clearly, the choices depend upon the chemical nature of the pollutants and the oceanography of the study area. Criteria include the ability of the organisms to accumulate the pollutant, the residence time of the organism in the study area, the physiological effects of the suspected pollutant, the size of the organisms, trophic level, and geographic distribution. The Panel has classified various groups of organisms for monitoring different types of pollution. There is a critical need for increased biological information on life histories of the fauna that appear most suitable or have the greatest ecological importance. The uptake and retention rates of pollutants are crucially required for potentially useful organisms. The Panel also recommends that laboratory tests of accumulation and retention rates for some important organisms should be established before new chemicals are introduced to the environment.

The Panel on the Design of a World Monitoring System pointed out that global oceanic monitoring will evolve from a series of regional networks which themselves will come out from national systems. Regional systems will give a real appreciation of the problems involved in running a global system and the Panel indicated that schemes at present being developed for the Baltic and North Seas will be most valuable in this respect.

The Panel reviewed existing and proposed programmes for monitoring the oceans and seas, as for example the IGOSS system and the discussion by the Group of Experts on Long-term and Scientific Policy and Planning (GELTSPAP) on activities under LEPOR. The implementation of such proposals depends not only upon continued seminars and colloquia but also, and of equal importance, upon the establishment of training centres for technical and managerial personnel involved in environmental work.

The Panel emphasised the need for an exploratory survey to establish the levels of various substances in the water column, the plankton, the benthos, the littoral zone, the sediments and the fish. With the presentation from the preceding panels and with the existing proposal for a sampling programme of the Study Group on Critical Environmental Problems at Williamstown in July 1970,the community of world scientists have demonstrated the existence of the necessary resources for such a baseline investigation.

In order to facilitate further technical consultations and steps to develop a world monitoring system a listing of laboratories pursuing the analyses of pollutants, considered at the Seminar, will be prepared for inclusion in the Proceedings.

Manual for the Detection and Measurement of Pollutants in the Marine Environment

The Seminar Report will be published as a part of the Conference Report. It is also intended to use the revised sections as a basis for the preparation of a Manual for the Detection and Measurement of Pollutants in the Marine Environment, to be published by SCOR as soon as possible.

Resolutions of the Seminar for Consideration by the Conference

The Seminar recommends the immediate establishment of a marine pollution citation index on the appearance of substances in the marine environment to provide an early warning system calling the attention of the scientific community to possible new pollutants.

The Seminar recommends that an exploratory survey of the world's oceans and seas be carried out at the earliest practical date in order to (a) establish the present levels and distribution of various pollutants in the waters, organisms and sediments; (b) provide data on which to base the design of a world monitoring programme.

LIST OF OFFICERS AND PANELS

Convener: E.D. Goldberg (USA)

Secretariat for the Seminar: G. Tomczak (FAO)
R. Marak (FAO)

Panel 1: Halogenated hydrocarbons (pesticides and PCB's)

R. Risebrough (Canada) Chairman
E. Huschenbeth (Germany, F.R.)
S. Jensen (Sweden)
J.E. Portmann (U.K.)

Panel 2: Petroleum

M. Blumer (USA) Chairman
P.C. Blokker (Netherlands)
E.B. Cowell (U.K.)
D.F. Duckworth (U.K.)

Panel 3: Inorganic chemicals (including mercury and lead)

D. Dyrssen (Sweden) Chairman
S. Keckes (IAEA)*
C. Patterson (USA)
J. Ui (Japan)
G. Weichart (Germany, F.R.)

Panel 4: Organic chemicals (particularly with regard to BOD and toxins)

G. Widmark (Sweden) Chairman
W.D. Garrett (USA)
M.P. Nestorova (USSR)*
K.H. Palmork (Norway)

Panel 5: Nutrient chemicals (including detergents and agricultural run-off)

J.P. Riley (U.K.) Chairman
K. Grasshoff (Germany, F.R.)
D. Menzel (USA)*
K. Sugawara (Japan)*
A. Voipio (Finland)

Panel 6: Suspended solids and turbidity

N.G. Jerlov (Denmark) Chairman
H. Postma (Netherlands)
B. Zeitzschel (Germany, F.R.)

Panel 7: Radioactivity

A. Preston (U.K.) Chairman
R. Fukai (IAEA)
J. Joseph (IAEA)
G. Polikarpov (USSR)*
H. Volchok (USA)
N. Yamagata (Japan)

Panel 8: Monitoring organisms

P.A. Butler (USA) Chairman
L. Andrén (FAO)
G.J. Bonde (Denmark)
A. Jernelöv (Sweden)
D.J. Reish (USA)

Panel 9: Design of World Monitoring System

A. Lee (U.K.) Chairman
E. Eriksson (WMO)
I. Haahtela (Finland)
B. Lundholm (Sweden)
S. Mizuno (WMO)
S. Saila (UNESCO/IOC)
A. Simonov (USSR)
J. Strömberg (Sweden)
V.B. Vouk (WHO)
M. Waldichuk (Canada)

* Unable to attend

ABSTRACTS OF CONTRIBUTIONS

1. ABSTRACTS

The following are the abstracts of contributions as presented to the Conference. Some additional papers were circulated during the Conference. These are not included here but most of them will appear in the Proceedings of the Conference, to be issued in book form as a co-publication with Fishing News (Books) Ltd., London.

Review papers

OIL CONTAMINATION AND THE LIVING RESOURCES OF THE SEA R-1

by

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Pollution introduces between 1 and 10 million tons of crude oil and oil products into the ocean per year. Coastal regions are more severely polluted and damaged than the open ocean. In man's design to provide for an expanding population the coastal regions are important, economically, esthetically and as sources of food. One-half of the total world fish production and nearly all of the shellfish production comes from the coastal regions, but oil pollution threatens the coastal environment, and adds to the growing stresses from sewage, insecticides, chemicals, overfishing, hot water discharge and the filling of wetlands.

All crude oils are poisons for all marine organisms; many crude oil distillates are more severely poisonous because they contain higher proportions of the immediately toxic compounds. Long-term toxicity may harm marine life that is not immediately killed by spills, and oil can be incorporated into the meat of marine animals, making it unfit for human consumption. Crude oil and oil products may cause cancer in marine organisms and in man; even at very low concentrations oil may interfere with processes which are vital for the propagation of marine species.

The most immediately toxic fractions of oil are water soluble; therefore, recovery of oil slicks is often futile, except for the esthetic improvement. Treatment with detergents, even the "nontoxic" ones, is dangerous because it exposes marine organisms to higher concentrations of soluble and toxic hydrocarbons and because it disperses oil into droplets that can be ingested and retained by many organisms. Natural bacterial action eventually decomposes spilled oil; however, the most toxic fraction disappears much more slowly than the more harmless ones and there is a possibility that the products of bacterial oil degradation are more toxic than oil itself.

Many misconceptions about oil pollution are widely distributed; some of them will be discussed.

THE EFFECTS OF POLLUTANTS ON THE REPRODUCTION OF MARINE ORGANISMS R-2

by

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Thermal pollution alters breeding seasons, and allows warm-water species to penetrate and breed in areas otherwise too cool for them. Similarly, cool-water forms may be prevented from breeding by temperatures that are too high. Furthermore, thermal pollution may allow an increase of production of fish, lobsters, etc. in cooler regions. Reduction of salinity by fresh-water effluents often reduces sexual activity and the number and strength of young.

Sea birds have been shown to develop thin-shelled eggs through the action of DDT residues, probably by influence of the insecticide on carbonic anhydrase activity in the shell gland. In salmon and trout, liberation of accumulated DDT residues after hatching, during absorption of the yolk sac, has led to high mortalities.

Experimentally, ducks fed small quantities of relatively non-toxic oils stopped laying eggs. Marine birds with oil-coated feathers transferred oil to their eggs during brooding, and the eggs failed to hatch, although they were fertile to begin with. Small quantities of oil led to injury and death of developing plaice eggs and larvae.

Sulphates reduced the percent of successful fertilization in herring eggs, and increased structural abnormalities in hatched fry. Sulphate pulp mill wastes reduced reproduction and settling of oysters but, conversely, kraft-mill wastes stimulated spawning by mussels. Abnormal development of sea urchin and pelecypod eggs has been used as a sensitive bioassay for the presence of small quantities of polluting metal ions, phenols, and other pollutants. Small quantities of radioisotopes affect cleavage rate, breakage of chromosomes, and incidence of deformities in eggs of fish, polychaetes and sea urchins.

POLLUTION IN THE BALTIC R-3

by

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The fjord conditions of the Baltic with a low-salinity surface water layer and a more saline deep-water layer make the deep water more or less stagnant, especially in the Baltic proper and adjacent areas. A slight increase in the salinity of the deep water during recent decades has been accompanied by a decrease in the oxygen content. Oxygen deficits are now common over many deep bottoms. The most pronounced oxygen decrease has occurred during the last few years and coincides with an increased phosphorus content.

Considerable and increasing amounts of sewage and industrial waste waters are discharged into the Baltic from all surrounding countries. The degree of treatment of waste waters is far from acceptable. No treatment plants include chemical precipitation of phosphorus.

Many coastal waters are seriously polluted. The main cause of the present oxygen deficit in the deep basins of the open Baltic is certainly stagnation, accentuated by the recent salinity increase. But also the oxygen deficit in deep waters may be caused indirectly by increased organic production in the upper water layers that results from increased nutrient supply from land. The yearly net supply of phosphorus to the whole area is estimated to be between 7,000 and 20,000 tons; most of it influences the area south of the Bothnian Sea and the Gulf of Finland.

A serious feature of the Baltic pollution is the high content of DDT and PCB compounds in fish and other organisms in the open sea. The concentrations exceed those from the North Sea animals. Mercury pollution has affected some coastal areas. It seems that resistant, toxic substances tend to accumulate in the Baltic because of the relatively long residence time of the water there. Oil pollution is a serious problem; radioactive pollution is strictly controlled. Other kinds of pollution, from warm water, from sandsucking operations, and from the deposition of mud and sludge, etc., are restricted to local areas where, however, they can cause trouble for fishing operations.

The laws against water pollution in force in the different countries are generally valid also for the coastal territorial waters, but the control of coastal waters is usually less strict than that of inland waters. International cooperation concerning Baltic pollution problems is growing. A net of fixed stations in the open sea has been surveyed more or less continuously by research ships from the different countries for more than one year.

TECHNICAL ASPECTS OF WASTE DISPOSAL IN THE SEA THROUGH SUBMARINE OUTLETS

R-4

by

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Sewage pollutants are commonly disposed of through submarine ocean outfalls. Simple outfalls discharge sewage out the open end of pipes along the ocean bottom. Multiple port diffusers to discharge the waste as a large number of small jets have become more common in recent years. The jets coalesce to form a waste cloud in which the initial dilution can easily reach 100:1. Additional dilution occurs from oceanic mixing as the cloud drifts away from the diffuser. If density stratification is present in the receiving water, one can often design the diffuser to keep the pollutant cloud below the ocean surface.

This paper reviews the methods for predicting the dilution from a submarine outfall, and for predicting the spread of the cloud in the ocean. Dilution diagrams are given for the rising jet, and for the spread of the cloud as it travels towards a shore. A method for predicting the effect of stratification on the height of rise of the pollutant cloud is described.

Hot water discharges from electric power stations also are of great significance to marine ecology. If they are discharged through submarine outfalls, the technology for disposal of sewage can be applied. Often, however, hot water is discharged at the ocean surface from outfall canals. The paper reviews recent studies of surface buoyant jets and their application to predicting temperature distributions in the receiving water.

WASTE REMOVAL AND RECYCLING BY SEDIMENTARY PROCESSES R-5

by

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Sediment particles have a substantial capacity to remove dissolved materials, including various types of wastes, from ocean water. This is especially important in coastal waters where particle concentrations tend to be high. These particles come from rivers, current scour of sediment deposits, fallout of airborne particles, and dumping of barged wastes from coastal cities. Most particles settle out near the point of discharge although fine-grained or low-density materials may be transported long distances. Dissolved wastes can be removed by ion exchange reactions, by precipitation and gravitational settling, or by biological processes. Once on the bottom, waste deposits may be isolated from further interactions with ocean water and organisms. If so, this may constitute an attractive means of waste disposal. Ocean waste disposal can also cause problems. Areas used for large-scale waste disposal operations may be devoid of normal benthic organisms. Wastes originally dissolved may become available to organisms by incorporation of particles which are ingested. Waste deposits may also constitute long-term regional problems if they release nutrients or noxious substances, as a result of compaction of fine-grained deposits causing expulsion of interstitial waters. Ground water discharge near coasts and stirring of the deposits by gas and bubble formation may also release dissolved materials from waste deposits.

TOXICITY OF MARINE ORGANISMS CAUSED BY POLLUTANTS R-6

by

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The problem of toxicity in marine organisms, due to either natural causes or man-produced pollutants, is coming into critical focus. About 50% of the world's total fish supply is derived from coastal upwelling regions comprising about .01% of the ocean's surface; the remaining half is produced largely in other coastal waters and the few offshore regions of comparatively high fertility. On the basis of the geographical distribution of the total marine biomass it is apparent that the most productive portions of the world's oceans are concentrated within the neritic rather than the oceanic region. The neritic region is most susceptible to the destructive forces of man-made pollutants because it is the region of greatest human activity.

A major part of the pollution problem is toxicological and concerns the toxic effects of a chemical substance on the cellular systems of an organism. Some of the most serious effects in the marine environment are low level and long term.

A growing amount of evidence indicates that pollutants may trigger "natural-occurring" marine biotoxicity cycles in tropical insular regions. When the proper mix of chemical constituents is present in the environment of certain types of marine organisms, biotoxins are produced.

Minamata disease has become a classical example of how industrial pollutants can become involved in the food web of marine organisms and finally produce lethal effects in humans. The mechanisms of the production of a toxic methyl mercuric salt is discussed.

Crude oils (petroleum) and refined oils are toxic for all marine organisms and for man. Poisoning may be immediate or slow and long lasting. Oil may be taken up in the tissues of shellfish and make them unfit for the market. Toxic hydrocarbons produce anesthesia, narcosis, cell damage, and death in a variety of lower animals. Crude oils contain hydrocarbons which are carcinogenic. To what extent these toxic hydrocarbons become protein bound and carry over in the food of man is not known.

Phenols and cresols present in industrial effluent may taint the flesh of food fishes and destroy their market value. Metals and dyestuffs, present in even very minute quantities, may taint or discolour the flesh of marine organisms and destroy their market value. The effect on humans is not known.

Thousands of halibut, croaker, seabass, sole, sand dabs, and other shore fishes taken along the Southern California coast and the New York Bight in the vicinity of sewage outfalls have had an alarmingly high incidence of cancerous growths, skin ulcers, malformations, emaciation, and genetic changes. These pathological disturbances are believed to be due to the toxic effects of pollutants. The precise causative agents are unknown. The possible public health implications to man are of growing concern.

The urgent need for developing a base line of fundamental biological, chemical, and pharmaco-toxicological data, literature retrieval, and communications systems is briefly discussed.

MARINE POLLUTION AND RESEARCH IN THE PHILIPPINES R-7

by

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At the present time marine pollution does not appear to be a major problem in the Philippines, except in a few tidal estuaries bordering the few industrialized centres of the Philippines. Most of these pollution cases deal with water pollution from domestic wastes and silt from mining companies. The problem is severe in areas close to the bay shores and the coastal regions near the mouths of the rivers that flow through these urban areas. A pollution control law has been passed and research has begun on pollution problems.

MARINE ALGAE AND THEIR RELATIONS TO POLLUTION PROBLEMS R-8

by

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Many human activities affect algae. Algal nutrients as well as toxicants occur in sewage and agricultural waste waters. Thermal effluents, petroleum spillage, dredging, and harbour construction can influence abundance and species composition of algal populations.

Pollution effects on algal growth range from serious depression to strong stimulation. Pollution-triggered algal blooms can produce undesirable side-effects (poisoning animals, reducing dissolved oxygen at night, odour production, water discolouration, etc.). Toxicants such as radioactive compounds and pesticides can be introduced to animal foodchains via algal uptake. Algal stimulation mechanisms, therefore, are equally if not more important than depression effects for comprehending consequences of marine waste disposal.

Known toxicants and depressants for marine algae include heavy metals (Cr, Cu, Hg, Ni, Pb, Zn), simple organics (benzene, cresol, hexane, phenol, toluene), various inorganics (Cl, CN, H_2S), and complex wastes (industrial sewage, sulfite waste liquor, petroleum compounds, detergents). Toxicity determinations using fresh-water algae suggest that many additional substances could influence marine algae.

Stimulatory substances occurring significantly in certain wastes include phosphate, nitrogen as ammonia, nitrate, and organic nitrogen, and silica. P/N ratios and concentrations of various forms of P and N may affect species composition as well as productivity.

Comparisons of organic nitrogen (as amino acids) uptake rates by "pollution" algae (Ulva, Enteromorpha) vs. other forms (18 macrophytes, 12 microphytes) offer an experimental basis to explain success of certain algae in organic-rich environments. Conversely some algae secrete organics copiously which might stimulate growth in certain animals.

A CRITICAL REVIEW OF THE USE OF MARINE INVERTEBRATES AS INDICATORS OF VARYING DEGREES OF MARINE POLLUTION R-9

by

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The use of invertebrates as indicators of pollution was first applied to the marine environment by Wilhelmi in 1916. He applied the concepts discovered earlier for polluted fresh waters by Kolkwitz and Mansson in 1908. Widespread description and application of the indicator organism concept for marine waters began some 15 years ago and has continued to date. Benthic invertebrate species have been favoured as indicators since they reflect

not only conditions at the time of sampling but for some time previous. Three to four zones have been employed to indicate varying degrees of pollution: (1) a healthy zone where population is normal and unaffected by any waste discharge, (2) a semi-healthy, or intermediate zone in which a reduction of species diversity is noted, (3) a polluted zone in which only two or three species are present and generally one of them is the polychaete Capitella capitata, and (4) a very polluted zone is used whenever the conditions are so heavily polluted as to exclude all macroscopic animal life. The polychaete Capitella capitata has been found to flourish wherever organic material accumulates, such as in the vicinity of sewage outfalls. This species has been useful as an indicator in polluted waters of California, Japan, France, and South Africa.

The use of invertebrates as indicators of varying degrees of marine pollution is critically evaluated and its application to current or future studies is discussed.

EFFECTS OF RADIATION IN THE MARINE ECOSYSTEM R-10

by

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Under the present expansion in the development of nuclear energy, the marine environment will inevitably receive an increasing burden of radiation. We need to be concerned then with the amounts and kinds of radiation the individual organism, populations and the ecosystem can tolerate without significantly changing the "balance of nature". This balance is not static. It responds variously to a multiplicity of factors, both natural and man-made. Radiation is but one of these factors.

This paper reviews our knowledge of natural background radiation, effects of acute and chronic external exposure, and internal emitters. The use of thermoluminescent dosimeter will be described as a method of defining radiation regimes in the environment. The influence of environment on radiation effects is discussed, as are effects of radiation on behaviour and metabolism. Relevant data from field studies at the Pacific Proving Grounds and in the Irish Sea will be discussed as it pertains to radiation effects.

Laboratory and field studies on population effects will be discussed, especially in relation to the potential effects on fishery resources and the ecosystem. Research needs for the future will be identified.

ESTUARINE AND COASTAL POLLUTION IN THE UNITED STATES R-11

by

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The coastal zone of the United States is divided into ten regions based on biological and physical similarities. These regions are designated North Atlantic, Middle Atlantic, Chesapeake Bay, South Atlantic, Caribbean, Gulf of Mexico, Pacific Southwest, Pacific Northwest, Alaska, and Pacific Islands.

Coastal and estuarine pollution problems in each of these regions are discussed with emphasis on their impact on the living resources of coastal areas. The locations of pollution problems in the United States coastal zone are the result of the historical development of population and industrial centres in these coastal areas, but their impact on living resources is closely related to the natural environmental characteristics of the regions.

Even more damaging than waste discharges, however, are the permanent environmental changes being caused by widespread dredging and filling of coastal areas. The changes have often resulted in the destruction of estuarine nursery areas of shrimp and other important commercial biota and in the alteration of water movement patterns which may affect entire estuarine systems.

The recently completed National Estuarine Pollution Study recommended a comprehensive national programme to manage coastal resources for optimum use while conserving and protecting their value to the entire nation. As part of its role in this programme, the Federal government has developed the automated information system known as the National Estuarine Inventory to assist the States by providing ready access to the great variety of information needed to make rational management decisions.

THE PRINCIPLES AND METHODS EMPLOYED FOR THE SANITARY CONTROL OF MOLLUSCAN SHELLFISH R-12

by

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The increasing exploitation of molluscan shellfish in polluted coastal waters poses problems for those concerned with the sanitary control of shellfish. The expansion of molluscan fisheries in developing countries and the increasing scale of international commerce indicate the need for an exchange of experience in this field, and a wider understanding of the principles and methods employed. Using examples, the basis for the sanitary control of molluscs in Europe and North America is discussed, including current bacteriological methods, and the advantages of assessing the sanitary quality of shellfish by analysis of sea water or of shellfish tissue. Current bacterial standards, including the value of several indicator organisms, are considered, with special reference to the transmission of viruses, and attention is drawn to the public health significance of non-faecal organisms of marine origin. The difficulties of applying current European standards to areas with a high disease carrier rate are considered.

THE CONSTRUCTIVE USE OF SEWAGE, WITH PARTICULAR REFERENCE TO FISH CULTURE

R-13

by

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A huge harvest of fish from aquatic systems fertilized with animal wastes, including those of man, takes place in the world. This fact is rarely mentioned in the scientific literature of western industrialized societies. Western attitudes about public health have undoubtedly mitigated against using waste waters in this way. There is, however, widespread use of "oxidation ponds" throughout the United States and the world by sanitary engineers. These ponds are analogous to natural waters that are fertilized by waste water discharges.

Fishery biologists have long been involved with the use of fertilizers in artificial ponds or natural waters to increase aquatic harvests. Therefore fish culturists and sanitary engineers have overlapping problems and they draw on similar knowledge in their work. The degree of overlap now occurring in the literature of these fields heralds a growing interdisciplinary approach to common problems.

Nutrients in sewage wastes can be used to grow harvestable aquatic products in sanitary, managed systems. Significant economic and social benefits can result from acting on Spilhaus' thesis - "Waste is simply some useful substance that we do not yet have the wit to use."

CORAL REEFS AND POLLUTION

R-14

by

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Coral reefs are among the most biologically productive, taxonomically diverse and aesthetically celebrated of all communities. They also constitute the most extensive shallow water community on earth. Despite these characteristics, the widespread degradation of coral reef communities by man has gone comparatively unnoticed. This is probably due to the essential invisibility of coral reefs to all but the skin diver. The contamination of reef communities by sewage and industrial wastes is commonplace. Siltation and water stagnation brought about by dredging have created serious problems on some reefs. The destruction of reef communities by silt-laden, low-salinity water from floods associated with land clearing can be expected to occur with increasing frequency. Since tropical marine organisms live within only a few degrees of their upper thermal limits, thermal pollution by nuclear power plants threatens to become a serious problem. Devastation of Pacific coral reefs by the starfish, Acanthaster, is thought to stem from man's unconscious shifting of ecological equilibria in the reef community.

Although corals usually account for only a minor fraction of total reef community biomass, when they die the entire reef community collapses due to the subsequent death or emigration of most other reef fauna. Thus the environmental tolerance of the reef community cannot exceed that of its coral component. Although the impact of man's activities on reef communities as a whole are very poorly understood, considerable information is available on the tolerance of various coral species to environmental stresses. This information should be used as a guideline for setting up provisional reef conservation regulations. If other vital components of the reef community prove to have narrower environmental tolerances than corals, such regulations might prove insufficient, but they would be a valuable beginning. Obviously information on the response of the entire reef community to pollution must be sought, but we cannot afford to wait until such information is available before taking steps to reduce reef pollution.

THE CONTROL OF MARINE POLLUTION AND THE PROTECTION OF LIVING RESOURCES OF THE SEA

R-15

A comparative study of international controls and national legislation and administration

by

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The paper deals first with the control of marine pollution at the international level, describing the present state of international law, both conventional and customary, and the activities of international agencies. The paper then analyses the main kinds of national legislation dealing with marine pollution, mentioning first some of the more general problems facing that legislation, such as problems of territorial scope and problems relating to its purpose. Some recent laws which do not conform to traditional jurisdictional concepts are discussed and the shortcomings of most national administrative structures are domonstrated. In conclusion the author points out the inadequacy of national legislation, as traditionally confined within territorial limits, to cope with marine pollution and argue for more international and regional control as the alternative to unilateral extension of national jurisdiction.

MARINE POLLUTION IN JAPAN

R-16

by

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Case studies of each pollutant and general surveys of pertinent areas are reported.

Cases studied include: green oysters in Nobeoka Bay and on the coast of Nagoya and Hitachi; decay of oysters and sea laver (edible algae) caused by food processing wastes in Matsushima Bay; carcinogenesis of laver and tainting of bivalves by coal slime in Ohmuta Bay; damage to fishing grounds in Akiake Bay by PCP; contamination of fish by odours from the effluents of petrochemical works in Yokkaichi and Iwakuni; disturbed formation of mother-of-pearl layers in oysters by dredging spoils in the Bisan Straits; and frequent red tides from eutrophication in Tokuyama and Ohmura Bay.

Environmental field surveys have included general observations and particular observations on the dispersion of various effluents and the deterioration of the sea bed and benthic fauna caused by organic and inorganic wastes. The influence of coastal discharges can be predicted by estimating the extent of dispersion. Comparative studies of pollution in the major embayments of Tokyo, Ise and Osaka have been made by examining the benthic fauna. Systematic investigations have been initiated and charts of the present status of pollution in different areas are being prepared.

BIOLOGICAL EFFECTS OF OIL POLLUTION IN THE SANTA BARBARA CHANNEL R-17

by

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This paper is the result of a 12-month study to determine the actual effects of the January 1969 oilwell blowout in the Santa Barbara Channel. The study was made over a 12-month period to determine not only the initial effects but some of the longer term effects of oil pollution. It also gave an indication of recovery in the area. The spill occurred in an area containing numerous natural oilseeps and during a period of abnormally heavy rains. These factors, as well as human interference, are considered when interpreting the data. Briefly, three main points emerge:

1. It is difficult to prove damage by oil pollution in the field
2. Damage to fauna and flora was not as great as expected
3. The area is recovering

Reasons for these results are discussed in the paper.

THE GULF OF ST. LAWRENCE FROM A POLLUTION VIEWPOINT R-18

by

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The Gulf of St. Lawrence, covering an area of approximately 60,000 mi^2 and nearly surrounded by land, can be considered as a large complex estuary. From the St. Lawrence River system, which extends inland approximately 2,000 mi to major urban and industrialized areas, the Gulf receives the drainage from approximately a half million mi^2.

Information is available on specific pollutants for some of the estuarial and coastal embayments situated around the Gulf, where pulp mills, mining operations, or other man-made activities have had obvious local effects. Little is known of the extent of these pollutants but it is possible that detectable effects may well be felt throughout much of the Gulf. In the past, large quantities of DDT have been used on New Brunswick's forests and serious damage has been observed on aquatic life in the rivers draining these areas. Although appreciable concentrations have yet to be confirmed in the supporting food chain, at least one gannet colony in the Gulf is suffering from the production of thin-shelled eggs. Preliminary information on mercury levels in fish taken from the Gulf indicates relatively low values.

The known general oceanographic features of the Gulf are reviewed and with this background information, comments and suggestions are offered for possible future research from a pollution viewpoint.

ASPECTS OF CONTAMINATION OF SEA WATER IN THE GULF OF MEXICO R-19

by

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This document reviews types of pollutants of the marine waters of Mexico; these include oil, sulphur, sugar mill effluent and agricultural wastes. The affect of 'aguas negras' (black waters) and heat are also described. The consequences of such pollution, in the form of ecological changes affecting marine fauna and flora, as well as the grave social consequences are reported.

There follows a discussion of measures being taken or that can be taken to prevent and eliminate such contamination, the main possible solutions and the legal aspects of this problem. A detailed description of the present situation is given, with short and long-term projections.

Attention is also paid to lagoons and coastal estuaries of such great importance to the economy of Mexico, as these are the breeding grounds and habitat for many species which particularly suffer from the effects of contamination. Mention is made of the problems arising from the tapping of the rivers which flow into the areas, whether it be for agricultural purposes or otherwise, of great significance in connection with ecological changes in these areas and stocks of certain exploitable marine species.

NORTH SEA POLLUTION R-20

by

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In 1968 the International Council for the Exploration of the Sea completed a factual survey of pollution reaching the North Sea and adjacent waters (published in 1969 as Cooperative Research Report, Series A, No. 13). Information was contributed by Norway, Sweden, Denmark, Federal Republic of Germany, Netherlands, Belgium, France and the United Kingdom. Legislation controlling pollution in the various countries bordering the North Sea was summarized and it was noted that this was in a state of development, with particular attention being given to: (i) the need to control pollution reaching the sea from major rivers running through several countries, such as the Rhine; (ii) the desirability of integrating legislation so as to control pollution from all sources; and (iii) the need to exercise restraint over the dumping of toxic materials in international waters outside territorial limits.

Factual information regarding pollutants was brought together under the following subheads: sewage pollution, industrial pollution, pesticides, and oil and detergents. For each category the situation in each member country was summarized. Methods and results of toxicity studies were reviewed and consideration was given to the need to support acute toxicity-testing with longer-term studies of sub-lethal effects.

Transport and diffusion mechanisms of importance in relation to the spread of pollutants were considered and this section is of great value in indicating the nature of the further research needed.

The report concludes with a comprehensive bibliography compiled from national sources among the member countries. There are appendices giving a series of maps pinpointing the major sources of pollution in Norway, Sweden and the United Kingdom, toxicity test data, and the text of the international agreement providing for cooperation in dealing with pollution of the North Sea by oil. This agreement may form the basis for wider regional cooperation in dealing with other pollutants.

Since the publication of the ICES Report in 1969 there has been a considerable development of research in several countries bordering the North Sea which has led to sharpened appreciation of the need to limit the discharges of toxic and persistent wastes such as organochlorine pesticides, polychlorinated biphenyls and heavy metals such as mercury, lead and copper. The importance of international cooperation in developing standards for the control of pollution discharges has become more evident.

The hazards which may arise from major river systems passing through several countries were clearly shown by the catastrophic effects of an accidental release of thiodan (endosulfan) into the Rhine in 1969.

A SYSTEMS APPROACH TO THE ECONOMIC ANALYSIS OF MARINE POLLUTION CONTROL

by

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The possibility of large scale contamination of the marine environment from planned and unplanned waste disposal is becoming real. Public attention has centered on the more dramatic incidents involving major oil spills and uncontrolled offshore oil and gas wells, but the insidious attrition of the productive capacity of nearshore and estuarine environments is probably of greater concern on a worldwide basis. At the same time, when used under proper control the assimilative capacity of salt water yields a flow of services of enormous economic value to mankind.

This paper develops the analytic framework of an engineering-economic system for evaluating conflicts arising out of waste disposal in the marine environment and for quantification of relevant variables to meet specific objectives. Particular attention is given to the dynamic aspects of the problem, because water quality parameters respond to continuous demographic changes and to the varying types of agricultural and industrial wastes generated in a growing economy. Thus, the analysis must not only assess the reduction in quantity and quality of marine products resulting from pollution but also the costs of abatement. The operational usefulness of a management system designed to use the assimilative capacity of the oceans with minimal damage to other economic outputs requires careful evaluation between precision and data costs' tradeoffs. Such systems also must be geared to the inherent difficulty of specifying damage functions where complex, interlocking populations of living creatures are involved, and thus point to the need for conservatism in establishing safe minimum standards for waste disposal.

Operation systems can be designed that do not require excessive data inputs and that permit substantial use of the oceans for disposal without offsetting damage to other users. Such solutions depend on vigorous exploitation of the fact that the total amount of waste generated can be greatly reduced through financial incentives to develop alternative methods not involving damage to other users of the sea. Thus, an adequate program for safeguarding the productivity of the marine environment is viewed as an integral part of the problem of assessing and assigning the costs of all waste disposal on a regional and international basis.

CHEMICAL AND BIOLOGICAL ASPECTS OF WASTE TREATMENT

R-22

by

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During the past decade considerable research has been directed toward improving existing biological and chemical waste water treatment processes and to the developing new processes for producing effluents to meet higher water quality standards. The increase in population and industrial concentration in urban areas requires more waste water treatment, with emphasis on the combined treatment of municipal and industrial waste waters. This paper reviews the chemical and biological processes used to remove organic and inorganic pollutants from waste waters. The effluent quality obtainable from these processes and the economics of treatment are presented. New waste water treatment processes presently under development are discussed.

GLOBAL MONITORING OF ATMOSPHERIC POLLUTION; ITS POSSIBLE RELATION TO A GLOBAL MARINE MONITORING SCHEME

R-23

by

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The paper emphasizes the close contact and intimate interactions between ocean and atmosphere. The classic example is carbon dioxide whose concentration in the atmosphere is to a considerable extent dependent on the physical and chemical state of the oceans. At present it seems likely that at least one-third of the fossil carbon dioxide released by man's activity enters the ocean through the sea surface. It is also possible that oceans contribute to the atmospheric burden of sulfur compounds by releasing hydrogen sulphide especially in coastal regions and particularly where large amounts of sewage is dumped into shallow waters. The role of the ocean-atmosphere system in the rapid global spread of DDT has been suggested but cannot be substantiated for lack of appropriate data. These circumstances indicate the need for a rather close connection between future monitoring systems for the oceans and the atmosphere.

The global background station network for atmospheric pollution promoted by the WMO is described in some detail. Data collection will take place at two types of stations; global baseline stations and regional background stations. The first category contains about ten carefully chosen stations to represent conditions over very large areas. The second category should represent regional features of atmospheric pollution. Elements which can be suspected to influence climate to a high degree e.g. carbon dioxide and turbidity of the atmosphere, are given high priority.

Methods of sampling, collection and analysis are either to be standardized or, through routine intercomparison programmes, to be made completely comparable. Data are to be published by special arrangement with willing member countries of the WMO.

It is emphasized that in any marine monitoring scheme those elements which are of particular interest in global atmospheric pollution should receive particular attention so that a proper coordination in the data collection is obtained.

THE STATE OF THE POLLUTION IN THE MEDITERRANEAN SEA

R-24

A Provisional Report

by

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Thirteen out of 21 countries bordering the Mediterranean (including the Sea of Marmara and the Black Sea) reported to the GFCM details on the state of the pollution on their coasts. These data have been used for a review on the state of the pollution in the Mediterranean, but as they are not yet complete the review may only be considered as provisional.

Laws against water pollution in inland and territorial coastal waters are in force in all countries. However, enforcement of the rules is insufficient in coastal areas. Domestic sewage is discharged in great quantities into the sea, either direct from the shore or by pipelines. In nearly all cases this sewage is untreated. In some cases it undergoes primary treatment but it is reported that treatment plants do not work correctly. Some areas, particularly the European coasts of the western Mediterranean are very heavily polluted. This is true especially during the bathing season when the population sometimes exceeds 1.5 to 2 times the normal figure.

Industrial pollution concerns mainly the same areas where domestic sewage already represents a risk. Crucial points exist particularly along the Spanish and French coasts (Barcelona, the coast from Sète to Toulon) and in the Gulf of Venice. Oil pollution is a big problem in coastal areas of oil producing and manufacturing countries, mainly in the eastern Mediterranean. Crude oil residues, in the form of tarlike lumps, have been found in great quantities spread over the surface of the whole Mediterranean. Pesticides are extensively used in nearly all countries bordering the western Mediterranean but also in some areas of the eastern basin. Damage has been recorded concerning kills of birds and all kinds of marine living resources. Other kinds of pollution, e.g. warm water pollution, are no problem at present but may be of more importance in the future.

MARINE POLLUTION IN AUSTRALIA
A REVIEW OF THE PRESENT SITUATION REGARDING PROBLEMS, RESEARCH INVESTIGATIONS AND MANAGEMENT TECHNIQUES

R-25

by

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The physical characteristics of the coastal plains, the nature of the surface drainage and of the continental shelf of the Australian continent are discussed. The climate and the current knowledge of the marine environment of the shelf area is briefly outlined. Information is lacking for a large extent of the contiguous seas.

The fishing resources and their exploitation are briefly detailed and these demonstrate the dependence upon near shore and estuarine stocks. The concept of water pollution control, being a part of resource management, is discussed and the Conference definition of pollution is accepted.

The legislative and institutional framework of the Commonwealth of Australia, its six federated states and the territories, is outlined together with comments on the situation with regard to standards for discharge into the marine environment in each state.

Potential sources of pollution around the Australian seaboard are outlined by considering the distribution of urban centres, the extent of sewerage treatment, and sewage discharges into the marine environment. The distribution of ports and oil terminals and primary and secondary industries, including the power industry is given. These potential threats are evaluated on the basis of known polluted situations. The lack of quantitative data is underlined for the whole of Australia.

The currently active research and management programmes, and those planned to commence in the immediate future, are discussed for each state and the Northern Territory. This catalogue is limited in extent, with regard to the length of coastline, but nevertheless at this stage the critical situations are concentrated in a few areas. However, the provision for environmental surveys of the magnitude and scope necessary, even in these areas is limited by the extent of funds available for all marine research.

The need for full-scale environmental surveys, such as that operating on Port Phillip Bay, Victoria, and recommended for Westernport Bay in the same state, is advanced for each of the inlets upon which the state capitals are situated. These areas should be linked with a chain of environmental monitoring stations in shelf waters around the coast. The necessity for ecological surveys around the coasts is also underlined. The possibilities of developing multiple-use situations are discussed particularly in respect to the use of heated effluents in mariculture.

MERCURY AS A MARINE POLLUTANT R-26

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Until recently man's activity did not contribute considerably to changes in the marine environment, but with the fast technological development in the last decades the direct or indirect disposal of various potentially harmful products and by-products into the seas and oceans became reality. Mercury and its compounds belong in this category and it is estimated that at present half of the annual input of mercury into seas and oceans (about 5,000 t) is the result of uncontrolled release from the industrial and agricultural use of mercury compounds. Locally, in Japan, the input of mercury into sea water and thereupon into edible organisms raised the content to a level which caused the death of more than 40 people. In Scandinavian countries strict regulations had to be applied to avoid similar tragedies.

The mercury concentration in sea water is very low, 0.03 to 0.27 ppb, but due to mercury's high chemical reactivity and biological toxicity its increase has a strong deleterious effect on organisms. The biological transformation of relatively less toxic forms of mercury into those with very high toxicity and its bioaccumulation directly from sea water or through the food chains returns the mercury to man in a concentrated form, which apart from direct toxic effects can also have a genetic effect.

These aspects of mercury as marine pollutant will be reviewed and the present status of our knowledge concerning the biogeocycle of mercury and the impact on marine organisms will be discussed.

SEA WATER POLLUTION IN VENEZUELA

R-27

by

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The Republic of Venezuela has more than 3,000 km of marine coast on the Caribbean Sea and the Atlantic Ocean. The topographic conditions and natural beauty along these coasts have contributed to the development of tourism and the fishing industry. The important demographic increase and the rapid industrial development, principally petrochemical, will create problems even more serious than the marine pollution found now in the various littoral zones. This will result in a difficult situation of public health and aquatic life.

In the present paper an account is given of:

a) The polluted sea areas along the Venezuelean coasts

b) The various causes; and values of pollution

c) The features of oil pollution, particularly in Lake Maracaibo

d) The origin and effects of pollution on the aquatic life and damage to the fishing industry. Laws, regulations, and possible solutions with regard to item (c)

e) The magnitude of oil spills which occurred from 1965 to 1969; fines applied and their total revenue

f) The life cycle of the existing species of shrimp in the Gulf of Venezuela and Lake Maracaibo

g) The annual volume of shrimp caught and the total revenue

h) Future industrial development in the areas considered which could increase the marine pollution; and pertinent solutions under study.

PRESENT NEEDS FOR SCIENTIFIC ADVICE IN THE PROCESS OF LEGISLATION ON POLLUTION

R-28

by

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A general appraisal of existing legislation on marine pollution indicates the necessity for a programme for international legislation and for fostering national legislation. Suggestions are made about the scope of application of world-wide and regional agreements. Political obstacles stand in the way of international control. Consideration must be given to the special interests of certain regions.

Marine pollution is a new problem created by an expanding technology and cannot be solved by orthodox legal methods and techniques. Legislation should be envisaged as a process accompanying the development of technical civilisation. It necessitates collaboration between lawyers and marine scientists.

A general scientific motivation is needed for introducing legislative measures. This would include forecasts of long-term trends in marine pollution, especially in particularly affected regions. Marine pollution should cease to be considered an "unknown", even at the risk of committing errors. Identification of sources of pollution should be made by scientists and accompanied by recommendations as to controlling and preventive measures. Limits of "permissible pollution" must be scientifically defined well before these limits are reached. Scientific advice is needed to establish legally recognised methods of measuring the concentration of pollutants, and the advice of scientists is needed on the legislative measures necessary for implementing research and monitoring programmes.

BIOLOGICAL SYSTEMS AND CYCLING OF WASTE HEAT ENERGY R-29

by

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Man-made energy conversion processes release large quantities of waste heat. These conversion processes are increasing at an apparent exponential rate. Uncontrolled, undirected release of waste heat can disrupt energy flow into useful biological end-products. Future schemes must channel this heat in a controlled and directed manner in order to enhance energy flow in a useful way in biological systems. Both terrestrial applications and aqua-culturing approaches are presently being attempted in pilot and demonstration projects, however, no commercially profitable application is yet in existence and a number of problems remain to be solved. Nevertheless, the pressing need to recycle waste materials, especially into useful foodstuffs may prompt economic subsidies. The development of this new economic philosophy may be accelerated due to the need to maintain environmental quality.

SUBLETHAL EFFECTS OF POLLUTANTS ON FISH R-30

by

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Some of the criteria on permissible levels of toxic substances in water will have to be changed since they have been derived from the results of short-term bioassays where mortality of fish was taken as a measure of toxicity. Results of the long-term bioassays and some field observations indicate that quantities much lower than lethal ones could either cause functional and morphologic disturbances in fish or change environmental conditions in the water ecosystem to such an extent that the existence of natural populations is endangered.

The fishery of a certain area can be impaired if the taste of fish is spoiled (as in the case with "phenol fish") or substances toxic for men are accumulated in the fish tissues (as pesticides).

In this paper an attempt is made to define the concept of sublethal effects on fish and review the literature on the effects of long exposure of several groups of toxic substances (phenols, detergents, heavy metals and pesticides) on fish.

WATER SEDIMENT EXCHANGE AND RE-CONCENTRATION OF POLLUTANTS THROUGH BIOGEOCHEMICAL PROCESSES

R-31

by

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Man's influence on marine sediments is registered in two ways, (1) as an increased accumulation of carbonaceous matter with a change in pH and Eh of the environment, and (2) burial of pollutants in the sediments. The first effect may change the reactions in the sediments and between the water and sediments. This leads to disturbances in the distribution of plants and animals. Two groups of the most important pollutants: heavy metals and pesticides are discussed. Special attention is paid to the problem of reconcentration by biogeochemical processes

POLLUTION PROBLEMS IN THE STRAIT OF GEORGIA

R-32

by

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As a semi-enclosed marine environment, the Strait of Georgia could be very susceptible to widespread pollution. At this time the chief causes of pollution are from pulp mills and sewage. However, the extent of pollution from these and other sources is at present entirely local, and a 5 year study of the open waters of the Strait has not indicated any general pollution of this environment. Unified governmental or international action is required to ensure the preservation of this environment as an important area for commercial and sports fisheries.

A REVIEW OF THE INFLUENCE OF POLLUTION ON BENTHIC POPULATIONS

R-33

by

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A general summary of the effects of different types of pollution on the benthic populations has been made from the data contained in the literature and through our own observations. In general, previous authors placed more emphasis on the action of the pollutants on the different species than on the population itself (biocoenoses and communities).

Four main types of pollution are envisaged:

1) Chemically dissolved pollution of urban and industrial origin. On both soft substrates and solid substrates one can delimit the zones where the composition of population, rather similar in the whole world, includes a certain pollution level. Quantitative and qualitative aspects are considered. The action of pesticides and herbicides, studied *in vitro*, is known only for some isolated species.

2) Thermal pollution. Because it acts in a particular manner on each species, no general plan can be given. The macrophyte populations seem to be more sensitive than the animal populations.

3) Pollution by solid residues. Generally devoid of so-called toxicity, these muds influence the populations by hypersedimentation.

4) Petroleum pollution becomes apparent in instances of disaster. Fuels appear to be more dangerous to macrobenthic populations than crude oil. They have a lasting effect on the equilibrium of the populations. The consequences of pollution by lighter products, which are difficult to discriminate from those of group 1, are practically unknown, at least at the population level, if not by particular species. Accidental pollution due to organochloride and organophosphoric compounds may be very serious if massive.

ASPECTS OF MARINE POLLUTION IN THE ANTILLES R-34

by

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Lagoons, harbours, estuaries, and mangrove swamps throughout the Antilles are seriously threatened today by the development of new resorts, communities, and a few heavy industries. The primary problem is that of sedimentation resulting from dredging, shoreline land fill, runoff from excavations, and sewage effluents. Ecological changes and death of a wide variety of bottom organisms frequently occur as a result of interment, poisoning, and oxygen depletion due to heavy silting on the bottom, and turbidity in the water. Important spawning, nursery, and feeding grounds for food fishes are being increasingly threatened by the lack of management of these inshore areas.

Effects of human population increases, compounded by advances in technology, lead to a rapidly expanding strain on the marine environment around the islands. Most of the larger settlements are faced with accelerating eutrophication and foul odours in waters surrounding them due to the dumping of sewage and garbage, and the death of marine organisms due to fuel and oil spillage from the proliferation of boats. Industrial growth, such as existing petroleum and aluminium refineries, has already resulted in serious chemical pollution of some areas. Expanding explorations for offshore petroleum deposits, plus heavy trafficking of oil shipments throughout the region mean imminent danger of critical damage to shores and reefs from oil spills. Pesticide residues are already proven or suspected to be deleterious to many species of aquatic animals in the Antilles.

The islands, both individually and as a group, must take urgent action to enact legislation, provide conservation law enforcement, and initiate in-depth studies to protect the marine environment from unrestrained industrial and real estate development, harmful effluents, over-fishing, over-collecting, and indiscriminate public works projects. Due to the lack of existing means for cooperation among the islands, these efforts should be coordinated by some disinterested international development organization like FAO or UNESCO.

DILUTION AND DISPERSION OF POLLUTANTS BY PHYSICAL PROCESSES R-35

by

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The first part deals with the influence of physical properties on duration of stay and on places of deposition of pollutants in the sea. The materials may be solids or fluids, which may be floating, dissolved or submerged. The next part considers the influence of the physical environment on pollutants. The more important dynamic factors, turbulence and currents, result in mixing or eddy diffusion and transport. Static parameters such as temperature, density and viscosity are also considered.

The different chains of energy transformation relevant to these physical environmental properties and their effect on pollutants are discussed. These include surface heating and cooling by radiation, which result in convection or layering, wind-generated surface waves and drift and other currents. The influence of other possible energy sources such as biological, chemical or artificial technical processes is usually negligible. Methods are reviewed and examples given of systematic studies of these processes, including theories and practical measurements.

The conclusions summarize the general results and indicate questions still open for research in the future.

Experience papers

ON THE PREDICTABILITY OF WASTE CONCENTRATIONS E-1

by

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The effect of waste disposal on the marine environment is often determined on a basis of tracer studies. These experiments are usually performed by observing the spread of fluorescent dyes or radioactive tracers released as an instantaneous point source in the area under consideration. The spread of substance, continuously released into the ocean from a given source, is determined afterwards by superposition of the concentration distributions resulting from different subsequent instantaneous releases. In this integration it is possible to consider the effects of decay and advective transport.

Owing to the nature of the diffusion phenomenon involved, it is extremely difficult to make accurate predictions of the distribution of the waste concentration, especially at great distances from the source. This is caused by the following circumstances:

1. In instantaneous release experiments a considerable effort is required in order to make a sufficient number of observations simultaneously for obtaining reliable lines of equal concentration.

2. The integration to determine the effect of a continuous release can be made only by introducing certain mathematical expressions to describe the development of the lines of equal concentration as found in the instantaneous-release experiments. The mathematical expressions must be adapted to the measured concentration distributions, e.g., by selecting the most probable values of numerical parameters within the mathematical expressions.

3. The duration of the instantaneous release experiments may be short compared with the time required to get equilibrium conditions with continuous release starting with a clean sea as the initial condition of integration. Then the integration implies extrapolation of the instantaneous release data beyond the period of time covered in the experiments.

4. A further uncertainty arises from the question whether the conditions prevailing during the restricted number of tracer measurements are representative for average conditions.

In the present paper it is shown that variation of mathematical expressions already within the margins allowed by the natural limitations of the measuring technique, in some cases has a considerable effect upon the concentration values calculated for continuous release conditions by means of integration. This is the case especially at great distances from the source and in the case of release of non-conservative substances. When interpreting the results of instantaneous release experiments by integration, one must be aware of the factors mentioned above, and try to evaluate their influence. It may lead to an insight into the magnitude of the inaccuracies in the concentration values predicted for continuous release conditions.

FULL-SCALE EXPERIMENTS ON DISPOSAL OF WASTE FLUIDS INTO PROPELLER STREAM OF SHIP

E-2

by

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A quantity of about 1500 tons of waste acid is discharged daily into the North Sea along the coast of the Netherlands from a discharge-vessel of about 1000 tons especially designed for this purpose. To obtain a high degree of initial mixing, the waste acid is disposed into the propeller stream of the ship. To determine the dilution obtained, measurements were made at sea during routine trips of the discharge-vessel, the only variation from the normal disposal procedure being the fact that rhodamine B was added to the waste acid for measuring purposes. The dilution of the rhodamine B, and hence the dilutation of the waste acid, was measured up to a distance of 800 m behind the discharge-vessel. Results of these full-scale measurements, which were performed during the summer of 1969, are presented together with theoretical considerations and model experiments.

EFFECTS OF LOW CONCENTRATIONS OF FREE CHLORINE ON EGGS AND LARVAE OF PLAICE, Pleuronectes platessa L.

E-3

by

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Many coastal electricity-generating stations which use sea water for their condenser cooling systems chlorinate the water at the point of intake to prevent development of fouling organisms. When the cooling water is discharged it usually still contains a low level of chlorine, and although this may be quickly dispersed by dilution, it is nevertheless of some importance to know whether it could affect marine organisms.

An investigation is being carried out on the effects of low levels of chlorine in sea water on the early developmental stages of certain flatfish, and results are given for acute and chronic effects on eggs and larvae of plaice, Pleuronectes platessa L. Acute effects are measured by 48 h LD_{50}, chronic effects in the egg, by morphological damage to the subsequently hatched larvae, and in the larva by changes in food intake.

THERMAL POLLUTION OF A TROPICAL MARINE ESTUARY

E-4

by

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The continual growth and movement of populations and the technological development of nations with accompanying industrial demands will require the construction of huge power plants in coastal areas. To prevent detrimental effects on sea food production, recreation and other usage, these plants must be favourably located and their heated effluent adequately disposed of in order not to disturb the marine balance. A study was undertaken to ascertain the effects of heated effluents on a tropical marine estuary. Results from field studies of the hydrography, chemistry, and quantitative ecology are closely correlated with detailed laboratory studies of thermal lethal limits of some important commercial and food-chain organisms. At sustained temperatures of 33°C, important macro-algae and sea grasses died. After the plants disappear, the diversity and number of animals decrease. There is only a slight recovery during cold winter months. Continued discharge of heated effluents will adversely affect the biota and will lessen the value of the area as a fisheries nursery area and recreational area. Adding heat to an estuary in the tropics causes critical problems because organisms are living close to their upper temperature tolerance limits.

INFLUENCE OF POLLUTION ON MARINE POPULATIONS IN THE MARSEILLES REGION

E-5

by

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1. Modifications in population composition

1.1 Solid substrata

Pure water	Polluted water
populations composed of	
Mytilus galloprovincialis (slopes)) *Cystoseira stricta* (shelves))	*M. galloprovincialis*
Corallina cf. mediterranea) *Cystoseira crinita*)	*Corallina cf. officinalis*
Halopteris scoparia) *Padina pavonia*)	*Ulva lactuca*

Soil factors (in particular, hydrodynamics) play an important part.

1.2 Loose substrata

Starting from the pollution source, a succession of concentric zones is observed: maximum pollution, azoic; polluted, poor in species (5, cosmopolitan); subnormal (alteration of the natural population through disappearance of sensitive species); normal population in pure water. A zone may be missing. Such permanent populations which are indicative of environmental conditions may serve to identify the degree of water pollution.

2. Modifications in quantitative composition

The concept of biomass increasing with pollution is reviewed.

2.1 On solid substrata

Average biomasses expressed in weight of dry organic matter (g per m^2):

Pure water		Polluted water	
populations composed of			
C. stricta	: 2226	*M. galloprovincialis*	: 1431
C. cf. mediterranea	: 232	*C. cf. officinalis*	: 253
C. crinita	: 1295		
H. scoparia	: 561	*Ulva lactuca*	: 338

In port areas, this biomass rises from 378 g/m^2 (the most polluted site) to 929 g/m^2 (least polluted site). The apparent increase in the (total) biomass may be due to the increase in organic limestone:

Pure water		Polluted water
populations composed of		
C. stricta	: 2383 g/m^2	M. galloprovincialis : 22832 g/m^2

Ratios of weight of organic limestone to weight of dry organic matter:

Pure water		Polluted water
populations composed of		
Mussel beds	: 10.81	15.95
Coralline populations	: 9.17	17.74

2.2 On loose substrata

Results are extremely variable according to the zone and locality studied:

Zone of maximum pollution: zero biomass
Polluted zone (biomass expressed in g/m^2 of dry organic matter) from 1 to 5.5
Subnormal zone: 6.5 to (in exceptional cases) 61
Normal zone: 3 to 7

POLLUTION IN THE MEDITERRANEAN BASIN (SOME ASPECTS IN THE NORTHWESTERN MEDITERRANEAN AND THE UPPER ADRIATIC: THEIR LESSONS) E-6

by

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From the time of Marion (1883) the bibliography of pollution in the Mediterranean includes some hundreds of references. One of the latest works, that produced by the FAST (Federation of Scientific and Technical Associations of Milan) at the symposium on the subject of sea protection held in Milan in April 1969, endeavours to summarize the body of knowledge on the consequences of pollution in the Mediterranean. Most countries bordering on this sea are concerned about these problems.

Data are available on chemical, bacteriological and radioactive pollution and its effects on marine organisms and public health. There are plenty of bacteriological data. However, only the regions of Marseilles (France) and Trieste (Italy) seem to have been studied in a more general way. The conclusions reached by the authors are extremely close. Bacteriological and chemical data (such as on detergents or solute oxygen) tally. Homologous plant and animal populations are very similar even in detail. It would be easy to draw up a balance sheet of the "current status of pollution" in most of the Mediterranean, with the use of certain widely scattered perennial benthic populations. Some pollution factors such as detergents and coliforms can be measured by routine analysis, which would increase our knowledge.

Since most waste enters the sea untreated, proper sanitary engineering particularly adapted to the specific problems of the marine environment must be developed. The "sea-cleaning power" of sea water cannot be regarded as sufficient. The Mediterranean, which is a closed sea surrounded by industrial countries in which mass tourism is increasing, is rushing towards complete pollution. Fragmented efforts by one or more bordering countries will not improve the position and we must combine our energies and knowledge, when necessary, under the wing of some international body.

ACTION IN VITRO OF DETERGENTS ON SOME MARINE SPECIES

E-7

by

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This study covers the action of 20 non-ionic detergents and 15 anionic base product detergents on Scolelepis fuliginosa and Capitella capitata (polychetes), Mytilus galloprovincialis (mollusc), Sphaeroma serratum (crustacean). The 12 concentrations examined fall between 0.1 and 800 mg/litre. The following have been defined:

1. For each concentration, the time required to kill an individual or all individuals subjected to test.

2. The median tolerance limit after 48 h and 96 h. The value and limits of each of these data are discussed. The greatest frequency of $DL50_{48h}$ for anionic detergents lies between:

10-25 mg/l for Scolelepis
1-10 mg/l for Capitella
over 800 mg/l for Mytilus and Sphaeroma

For $DL50_{96h}$, the greatest frequencies are:

0.1-1 mg/l and 10-25 mg/l for Scolelepis
1-5 mg/l for Capitella
10-25 mg/l and over 800 mg/l for Sphaeroma
5-25 mg/l for Mytilus collected in polluted water
1-10 mg/l for Mytilus collected in pure water

For non-ionic detergents, the greatest frequencies of $DL50_{48h}$ and 96h are lower:

Scolelepis : $DL50_{48h}$: 0.5-5 mg/l
Capitella : $DL50_{48h}$: 1-5 mg/l
} $DL50_{96h}$: 0.1-2.5 mg/l
Mytilus : $DL50_{48h}$: 1-25 mg/l
$DL50_{96h}$: 0.5-5 mg/l

Sphaeroma : $DL50_{48h}$: 10-100 mg/l
$DL50_{96h}$: 5-50 mg/l

Non-ionic detergents are from 1.5 to 2 times more active than anionic detergents. Polyoxyethylenated straight-chain alcohols are more dangerous than alkyl aryl sulphanates. The four species may be classified in order of increasing sensitivity: Sphaeroma, Mytilus collected in polluted water, Mytilus collected in pure water, Capitella and Scolelepis.

WASTE WATER TREATMENT IN CHEMICAL INDUSTRIES IN THE FEDERAL REPUBLIC OF GERMANY

E-8

by

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The establishment of big industrial plants on the coasts and the growing difficulty experienced by inland factories in disposing of their effluents has in recent years led to an increased dumping of solid or liquid waste products into the sea. This has called for protective measures, applied particularly to coastal areas. The chemical industry manufactures a great number of different products by highly different processes which are subject to rapid technical development and involve particular problems of effluent disposal. By means of examples it is demonstrated that the major part of the resulting effluents can be treated in the plants to such an extent that only small quantities need be disposed of. Modern operations, internal methods of purification, special equipment for the disposal of effluents and waste products as well as special incinerators all contribute in varying degrees to the prevention of pollution. A number of difficulties nevertheless still exist which at present can only be overcome by the not inexpensive method of dumping the effluents at suitable points along the sea.

A TRAWL STUDY IN AN AREA OF HEAVY WASTE DISCHARGE: SANTA MONICA BAY, CALIFORNIA

E-9

by

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A trawl study was conducted in Santa Monica Bay, an area of large-scale waste disposal, during the years 1958-1963. It was hoped that information on the occurrence and distribution of bottomfish in this area would reveal the effects of waste disposal on their populations. In all, 705 bottom tows in 60 to 600 ft of water yielded 112,799 fish of 104 species, plus a number of unidentified juvenile rockfish. Five species made up the bulk of the catch. There was a moderately high yield of fish per tow in 1958, an extremely low in 1959, a build-up in 1960, a high in 1961, and a moderate drop in 1962 and 1963.

It was impossible to show that fluctuations in abundance, as measured by trawl catches, were the result of waste discharge in the study area, and not due to natural causes. The sport catch for the years 1958 through 1963 in Santa Monica Bay showed only small fluctuations. Artificial reefs in Santa Monica Bay offered evidence that giant kelp was unable to survive in areas affected by the "fallout" of particulate matter from waste discharges, and possibly from turbidity from the same source.

On the basis of this study it can be recommended that, if wastes must be discharged into coastal marine waters, the best place for the discharge is over the least productive bottom available, well offshore. This should be determined before discharged is permitted. Where currents carry the effluent and it reaches the rocky nearshore environment and artificial reefs, there is evidence of severe damage and inhibition of reproduction of giant kelp and probably other sessile organisms. Outfalls should be placed as far as possible from this type of environment.

USE OF POTENTIAL LAGOON POLLUTANTS TO PRODUCE PROTEIN IN THE SOUTH PACIFIC

E-10

by

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The South Sea Islands are spread over nearly one-quarter of the globe, in the greatest of oceans, and hardly cover 1% of the water surface. Therefore a huge expanse of clear and unpolluted water has always taken care of small amounts of pollutants by natural processes. The clear lagoons bordering the innumerable atolls and low-lying islands are abundant with marine life that has always been a source of healthful food for the islanders.

Many human activities, resulting from the commercial exploitation of these places, have upset this ecology, with very undesirable effects on the fish and shell populations. The most dangerous is the discharge of raw human excreta into these relatively still bodies of water, because it can start a chain reaction that adversely affects marine life. Sanitary disposal of these wastes, making use of all the products obtained during the carbon, nitrogen and water cycles, can prevent this pollution and, with the action of the ever-present sunshine in these tropical areas, provide an important source of protein for animal feed, nutrients for fish culture, and a stabilized effluent full of mineral salts for vegetable gardening.

THE BIOLOGICAL EFFECTS OF OIL POLLUTION AND OIL-CLEANING MATERIALS ON LITTORAL COMMUNITIES, INCLUDING SALT MARSHES

E-11

by

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Methods for surveying shores are described and results from the use of these methods discussed. Studies of accidental pollutions and experimental plots have verified that oil, except in large quantities, has little effect on the intertidal fauna and flora. Emulsifiers of the type commonly used in oil pollution emergencies, although more toxic than fresh crude oils, do not cause large mortalities on littoral organisms unless used heavily.

Both field and laboratory investigations have demonstrated that some species have a higher sensitivity to emulsifiers. Among plants, annuals are particularly susceptible while the limpet, Patella vulgata, is the most susceptible of common British shore animals. Simply measured limpet population parameters can be used to monitor the recovery of the community structure of rocky shores. The sensitivity of the limpet reveals that even light treatment with emulsifiers (including the new "less toxic varieties") is likely to be as damaging as prolonged cleaning. Experimental evidence from oil and emulsifiers shows that damage is greater in early spring than in other seasons.

Observations and experiments were made on the effects of chronic pollution after localized but marked damage was observed in the vicinity of oil refinery outfalls. In some sites continued discharge of slightly oily water (10-25 ppm) has resulted in the exposure of shores to large volumes of oil. Some of the ecological changes were reproduced experimentally on salt marsh vegetation. It is suggested that this type of damage could be minimized by simply re-siting effluent discharge pipes in deep water areas of greater tidal disturbance. Laboratory experiments on plant material to investigate the mechanisms of oil and detergent damage are described. Results indicate cell membrane breakdown followed by mitochondrial damage, uncoupling and abnormal respiration rates prior to death.

PESTICIDE-INDUCED STRESS PROFILES E-12

by

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Results of acute toxicity bioassays with selected organochlorine and organophosphorus insecticides and various species of marine teleosts, crustaceans, and molluscs are summarized; physico-chemical factors known to affect mortality patterns are listed. A profile technique is developed to evaluate effects of sublethal levels of pesticides to marine fauna, and is based on the hypothesis that metabolic disturbances have a far greater probability of detection if a number of parameters are simultaneously determined and plotted. Examples are presented of pesticide-induced stress in selected marine species utilizing as parameters hemoglobin, serum proteins, esterases, and other blood constituents, concentrations of zinc, calcium and other cations in selected tissues and whole animals. Visual patterns that are produced by these profiles afford an index useful for identification of unfavourable environmental conditions before obvious morphological or physiological changes occur. Ultimately, it could become feasible to correlate specific profiles with individual toxic agents.

SUBLETHAL CHRONIC EFFECTS OF DDT AND LINDANE ON GLYCOLYTIC AND GLUCONEOGENIC ENZYMES OF THE QUAHOG, *Mercenaria mercenaria* E-13

by

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Separate populations of *M. mercenaria* were exposed to 2 µg/l of DDT and lindane in running sea water for a period of 30 weeks, at which time a number of key glycolytic and gluconeogenic enzymes were assayed in foot, gill and mantle tissue. Enzyme levels in the DDT and lindane-exposed quahogs were compared with those from quahogs maintained in a control water table. Enzyme activities were also determined on a group of quahogs taken directly from the marine environment.

Normal quahog tissue was found to contain the following enzymes: hexokinase, glucose-6-phosphate dehydrogenase, phosphofructokinase, fructose diphosphatase, pyruvate kinase, phosphoenolpyruvate carboxytransphosphorylase and lactic dehydrogenase. Although the catalytic activities were extremely low (approximately 5% of rat liver on a tissue weight basis), when compared relative to hexokinase levels in each tissue, a general similarity in proportional activity between molluscan and mammalian tissue becomes apparent. During restricted food intake, control quahogs showed depleted glycogen reserves, a lowering of glucose-6-phosphate dehydrogenase and an elevation in fructose diphosphatase activity, indicating the operation of regulatory mechanisms analogous to those of mammalian tissue.

Superimposed on these changes, DDT-exposed quahogs showed a reduction in foot fructose diphosphatase (40%) and gill glucose-6-phosphate dehydrogenase (100%) and an increase in gill phosphofructokinase (70 permille). Lindane exposure resulted in a similar reduction in foot fructose diphosphatase (30 permille). The data indicate that chronic administration of sublethal doses of chlorinated hydrocarbons to the quahog could result in enzyme alterations indicative of an increase in the rate of glycolytic degradation of glucose and suppression of gluconeogenesis.

ACCUMULATION AND METABOLISM OF DDT-^{14}C (DICHLORO-DIPHENYL-TRICHLORO-ETHANE) IN MARINE ORGANISMS

E-14

by

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The scope of these studies was to measure the accumulation of DDT in marine worms from very dilute solutions and after oral application in short-term studies. In consideration of the fact that the worms used are food organisms for flatfishes, which are consumed by man, the transmission of DDT to fishes was studied with correlated concentrations, thus simulating a part of the foodchain. Experimental animals were from the North Sea and the Weser estuary, occurring here in abundant numbers.

1. Accumulation of DDT by marine worms:

Nereis diversicolor and Lanice conchilega. The animals were kept in sea water solutions of DDT at the following concentrations:

0.01	0.05	0.10	1.0	2.0	10 ppb (Lanice conchilega)
0.3	0.75	3.0	30.0		ppb (Nereis diversicolor)

Furthermore, Nereis diversicolor were given DDT orally in single and repeated doses of 1-5 µg/animal. Varying time of exposure and recovery, DDT concentrations in the worms and in the coelomic fluid of Lanice conchilega were in the ppm range.

2. Transmission and accumulation of DDT in flatfishes:

Platichthys flesus and Solea solea. DDT doses were administered orally and the distribution of the pesticide was measured in different tissues (brain, flesh, viscera, liver, kidney) and in the excreta. The time-dependent absorption from the gastrointestinal tract and the occurrence of DDT in the brain were determined. DDT levels were found in the ppm-range.

The metabolic products of DDT were examined in all experiments by radio chromatography showing degradation to DDE, DDD and more polar compounds. Experimental data are discussed in consideration of the residue tolerances of this pesticide in other foodstuffs. Experimental procedures will be discussed in detail.

AUTOMATION OF MONITORING EQUIPMENT FOR MARINE POLLUTION STUDIES

E-15

by

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To develop a system for automatic monitoring requires an initial definition of marine pollutants in strict chemical terms. It is difficult to establish the limits of such a definition because many naturally occurring substances function as pollutants under special conditions or in high concentrations and because some substances are effective pollutants at very low concentrations.

A preliminary classification scheme for marine pollutants is based on a combination of function and chemical characteristics. The three general categories are trace and heavy metals, organic compounds, and nutrients. The latter category is included because, in many cases, deleterious effects on the marine environment are caused by excessive quantities of nutrients introduced by man.

Automation of classical analytic methods for some members of each class of pollution has already been demonstrated. These include automation of emission and atomic absorption spectrophotometry for trace and heavy metals, automation of colorimetry for nutrients including phosphate, nitrate and others, and automation of gas chromatographs for the analysis of organic pesticides and hydrocarbons.

Major problems exist in the development and deployment of rugged non-contaminating sampling systems, in automation of sampling and concentration procedures, and in providing adequate quality control of automatic analyses.

Techniques for data processing and storage applicable to automatic marine pollution monitoring are adequately developed. The specific characteristic of such data systems will depend on the types of instruments included in the system and on the end use requirements of the data.

TOXICITY OF CRUDE OIL AND DETERGENTS TO TWO SPECIES OF EDIBLE MOLLUSCS UNDER ARTIFICIAL TIDAL CONDITIONS

E-16

by

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An investigation of the relative toxicities of partly-evaporated Arabian Light crude oil on its own and with two detergents in turn - Corexit 7664 and Dispersol OS - was made under artificial tidal conditions using the periwinkle, Littorina littorea, and the mussel, Mytilus edulis. The tidal regime in each experiment was followed by a period of recovery in clean tanks which remained filled with water. Parallel experiments (for both tidal and recover phases) were conducted at controlled temperatures of 4.6°C and 11°C.

It was found that in the tidal regime both oil/Corexit and oil/Dispersol were immediately toxic to L. littorea (28-30 out of 30 experimental animals were "dead" within 1 h). Oil alone was less toxic; TD_{50} = 2 - 12 h depending on temperature. When the L. littorea were transferred to the non-tidal tanks of clean water, recovery from both oil/detergent and oil alone was seen to take place to varying degrees, mainly depending on temperature with the lower temperature (4.6°C) more favourable.

Oil alone was seen to have no apparent toxicity towards M. edulis in the tidal regime. A peculiar effect was observed with oil/Dispersol at 4.6°C, where there was high initial toxicity (21 out of 30 animals) followed later in the tidal regime by partial recovery. This in turn gave way to normal progressive mortality. This pattern was not observed at 11°C, or with oil/Corexit at either temperature, and is suggested to have been caused by the persistence of the Isopropanol fraction of the Dispersol. When transferred to clean tanks, no recovery was seen to take place among the M. edulis subjected to oil/detergent pollution. The ecological aspects of the results are discussed.

PHYSIOLOGICAL STUDIES ON THE TOXICITY OF VARIOUS CONSTITUENTS OF SEA WATER

E-17

by

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As part of the research in progress on the pollution of coastal regions by industrial effluents, an analysis has been made of the waters polluted by the different chemical industries and of some chemical substances as well. The values found may serve as a yardstick for the degree to which water is polluted, as the injuriousness of industrial effluents can be most accurately gauged by research on physiological reactions in the organisms, and as the metabolic-physiological behaviour and the neural reactions of fish are subject to existing conditions in the external environment. Research has been done on:

1. The basal metabolism of plaice, eels and shrimp measured in terms of oxygen consumption in the entire body and of respiration through gill tissues.
2. The alteration in the composition of the blood by the toxins in polluted waters, by determining the quantity and surface of the erythrocytes and the hematocrit value.
3. The conductibility of the body of the fish. The reactions of fish in an electric field are examined by a special testing apparatus to record the physiological changes in nerves caused by different polluted waters.
4. The functional potential of the nervus lateralis. These measurements are particularly instructive when the material to be examined is a kind of "neurotoxin", for example, a herbicide.
5. The functioning of the heart by electrocardiogram.
6. The K and Na content of the entire animal and of the serum.
7. Histological changes in the gills.

The different methods are noted and the research findings obtained are reported with illustrative examples.

ECOLOGY OF THE ESTUARY OF THE LOWER HUDSON RIVER

E-18

by

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The Hudson River is a major waterway of the American East Coast, yet it has been relatively neglected by scientific studies, in spite of its undoubted importance for transport, industry, recreation, and as a source of potable water. Only in the last decade have systematic studies been initiated. These studies embrace water chemistry, dissolved oxygen, oxygen demand and bacterial levels, and quantitative studies of plankton, benthos and fish populations. At present, increasing industrial development following population growth in the area, and a rising standard of living are responsible for more demands on the river. It will now be necessary, if serious pollution problems are to be avoided, to make predictions about the single and synergistic effects of increasing nutrient loads, increasing heat inputs, and withdrawing an appreciable proportion of the river flow.

Recent studies have included predictions from mathematical and physical models, monitoring of basic physical and chemical data at a number of sites, studies of phyto- and zooplankton seasonal changes, and extensive studies of fisheries. In addition, a survey of radionuclides and pesticides in the water, muds and selected species of the biota has been followed for several years to evaluate pathways of these pollutants in the aquatic ecosystem.

THE DISCHARGE OF NUTRIENTS FROM ESTUARIES AND THEIR EFFECT ON PRIMARY PRODUCTIVITY

E-19

by

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Estuaries are the major pathways for the transfer of nutrients to the sea, but investigations into the effects or the amounts involved are few. The effects of nutrient additions to the North Sea are discussed here in relation to detailed surveys carried out on the River Tyne and calculations of the amounts contributed by the major estuaries of Great Britain and North Europe.

Of an input of 9.2 tons per day of nitrogen in the Tyne estuary, only 5 tons per day are discharged to sea, the remainder mainly accumulates in the bottom deposits. Between high and low water the material discharged from the estuary builds up as a plume of nutrient-enriched low salinity water within 10 km of the coast. This can be modelled as a buoyant jet discharging into a denser liquid and the distribution of salinity and nutrients predicted. During the flood tide the plume is displaced southwards and further dispersed. During the summer the biological utilization of nutrients results in an almost complete removal of nutrients from the coastal surface water. Within the discharge plume, appreciable amounts of nutrients are maintained in spite of higher standing crops of phytoplankton as compared with the coastal water.

The effect of the River Tyne discharge, both locally and in the North Sea as a whole, is small but calculations of the total amounts of nutrients entering the North Sea suggest that a slow build-up is occurring.

TRACE ELEMENTS, RADIONUCLIDES AND PESTICIDE RESIDUES IN THE HUDSON RIVER

E-20

by

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Studies of trace contaminants in the Hudson River and their bio-concentration in selected biota have been in progress at the Institute of Environmental Studies (New York University) since 1964. The relative distribution of radionuclides in the water, sediments and biota is similar to that reported in other areas for radionuclides and their associated stable elements. The natural radionuclides potassium-40 and radium-226 and -228 account for 80 to 90% of the activity in the river; the greater part of this is attributable to potassium-40. Except for tritium, man-made radioactivity in the river water is less than 1/100,000 of the AEC regulatory limits. Bioaccumulation of several man-made radionuclides have been studied. Of the nuclides selected (manganese-54, cobalt-60, iron-55, cerium-144, strontium-90) only manganese-54 and cobalt were found to be reconcentrated in measurable amounts. Accumulated activity does not increase with trophic level in the food web, but is governed by other factors.

Pesticide residues of the chlorinated hydrocarbon type have been shown to follow a pattern of increasing concentration with trophic level in many aquatic systems. This has been found to be true in the biota of the Hudson River with predatory fish and birds at the climax of the food web showing the highest concentrations, with some residues reaching concentration of 1 to 3 µg/g sample. This implies a biological magnification of over 100,000 from the maximum concentrations observed of a few nannograms/litre in the water. While no data have been obtained which would indicate biological effects on the species or population observed, there is less than a factor of 10 between the observed levels, and those reported elsewhere to be lethal to some species. For at least two species of fish sampled, pesticide residues exceed the current Food and Drug Administration guideline concentrations for edible portions of fish.

TISSUE LEVELS IN ANIMALS AND EFFECTS CAUSED BY CHLORINATED HYDROCARBON INSECTICIDES, BIPHENYLS AND MERCURY IN THE MARINE ENVIRONMENT ALONG THE NETHERLANDS COAST

E-21

by

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Since 1965 a toxicological surveillance has been made along the Netherlands coast. Molluscs, fish and sea birds were sampled and analyzed to follow the topographic distribution of the contamination, to note its effect on the foodchain and to correlate tissue residues with effects which might be due to the intake of the contaminants. Among the sea birds a large colony of sandwich terns (Sterna sandvicensis) in the Wadden Sea was found suffering from serious mortality in 1965. The cause could be attributed to pollution with chlorinated hydrocarbon insecticides. In the same area the eiderduck (Somateria mollissima) seems to be endangered by the influence of pollution, particularly the female eider due to its peculiar breeding habits.

By gas chromatography in combination with mass spectrometry a large number of isomers of polychlorinated biphenyls could be found in marine organisms. The toxicological implications of these substances will be discussed. With neutron activation and gas chromatographic methods, total mercury and methyl mercury levels were determined. High residues have been found, for example in some eiderducks. It is not yet possible to evaluate the residue levels of mercury in terms of risk to the ecosystem.

Distribution studies revealed that the contamination originated mainly from the River Rhine. The chlorinated hydrocarbon insecticides pollution could be traced back partly to a manufacturing plant close to the mouth of the river.

PROBLEMS AND APPROACHES TO BASE-LINE STUDIES IN COASTAL COMMUNITIES

E-22

by

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Base-line studies must provide data whereby future population changes can be ascribed to natural or man-made influences. A long-term study of population dynamics of rocky shore invertebrates demonstrates the complexity of natural fluctuations and their causes, and leads to the following conclusions:

1. Field censuses must encompass variation arising from marked heterogeneity of the local biological/physical environment, longevity differences under different biological conditions, and fluctuations that are seasonal, annual or highly irregular.

2. Meaningful interpretation of numerical data requires an understanding of age structure. This depends upon knowledge of (a) reproductive cycles, repopulation rates, age determination criteria, size/age relationships under different growth conditions, and mortality, and (b) the effect upon such parameters of the biological influences (within the community and from external predators) operating at each site over previous seasons.

3. An understanding of causes of variation in repopulation rates necessitates (a) annual comparisons of gonad cycles; (b) distinction between very local and very widespread fluctuations; and (c) information on growth/mortality, etc. during the planktonic and/or subtidal stages (where applicable).

4. Monitoring on a geographical scale will permit climatic/hydrographic influences to be distinguished from very local factors, but the gaining of such data necessitates a cooperative (international ?) effort.

5. The interactions between the littoral, subtidal and pelagial spheres are such that a full understanding of natural fluctuations in littoral and probably all coastal populations requires all three spheres to be included simultaneously in one comprehensive, long-term study.

The practicability of this "ideal" and other less comprehensive approaches is discussed in relation to the aims of base-line studies.

TOXICITY AND DEGRADATION OF TENSIDES IN SEA WATER E-23

by

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Between 1950 and 1960 synthetic tensides replaced the "natural" soaps so far in use in households and industries. Tensides get into the waters through sewage, passing into the coastal regions and into salt and brackish waters. Studies should therefore be undertaken to find if the toxicity of tensides is affected by salinity. A number of experiments has been carried out on eels and other fauna present in the coastal waters. During all experiments it was found that the toxicity of the tensides increased with increasing salinity. The following investigations showed that surface pressure decreases with increasing salinity. From experiments in fresh water we know that a surface pressure under 50 dyn/cm is dangerous for fish. Therefore it is believed that lowering of the surface tension in salt water is the responsible factor for the greater toxicity of tensides in brackish and salt water.

In Germany in connection with the Detergents Law of 1969 it was determined that only biologically decomparable (soft) tensides are allowed in trade. In practice the formerly used tetrapropylenbenzolsulphonate with a branched alkyl chain is decomposed by 30%, whereas the new products with a straight chain are decomposed by 90%, in which case the unsatisfactory characteristics disappear. All these observations concern fresh water. Investigations were made on the decomposition of soft tensides in a model plant for biological sewage treatment. During experiments with different salinities the introduced "soft" detergents were decomposed by 80 to 90%.

THE OCCURRENCE OF HUMAN VIRUSES AND COLIPHAGE IN MARINE WATERS AND SHELLFISH

E-24

by

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A study of the presence of human virus pathogens and coliphage was conducted in an estuarine environment subject to pollution by domestic raw sewage. Comparative examinations were made of the frequency of occurrence of enterovirus and coliphage in samples of oysters, overlaying water and waste treatment plant effluents being released into tributary rivers comprising part of the estuary. Isolation rates (number of recoveries/number of samples tested) for virus and coliphage were established in joint examination of test materials. Survival values (days detectable virus demonstrated) for each group were determined in estuary waters. The retention rate (days detectable virus recovered) in oysters stored in estuary waters following experimentally-induced virus and coliform carriage was determined by assay of oyster pools. The influence of season, temperature and extent of pollution upon isolation and survival values, and retention rates in oysters was determined for virus and coliphage.

The data presented supported the following conclusions: (1) Coliphage was found more frequently than enterovirus in all kinds of samples examined. (2) Enterovirus occurrence fluctuated widely from week to week in the summer, and from season to season. (3) Fluctuations in weekly and seasonal occurrence of coliphage did not parallel enterovirus variations. (4) Enterovirus usually persisted longer than coliphage in the estuarine environment.

Results of the study indicated coliphage could not be used to reliably predict the presence of human viruses in a polluted estuarine environment. The significance of the findings to public health problems involving sanitary examinations of estuary waters and shellfish are discussed.

MYCOLOGICAL DEGRADATION OF PETROLEUM PRODUCTS IN MARINE ENVIRONMENTS

E-25

by

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Yeasts and yeast-like fungi in estuarine and marine waters rarely exceed 500 viable units/100 ml, although significantly increased densities are observed in organically-enriched habitats. The feasibility of using species distribution patterns as indicators of water quality is suggested. In coastal marsh sediments, concentrations as great as 9×10^4 viable yeast units/cm^3 are encountered. The pollution of waters or beaches with oil may result in drastic alteration of the normal yeast biota, with concurrent increase in numbers of hydrocarbonoclastic species. These latter, commonly strains of Rhodotorula and Aureobasidium, utilize a range of hydrocarbons, including alkanes from C_{10}–C_{18}, kerosene, diesel fuel, and tractor fuel. Respiration of mixed populations of selected yeasts and bacteria grown on crude oil fractions is greater than that obtained with individual organisms. The use of mixed microbial populations in the control and facilitation of decomposition of oil spills is postulated, using mechanisms or "systems" of dispersal such as microencapsulation.

ANTAGONISM OF THE NATIVE MICROFLORA TO MICROBIAL POLLUTANTS IN THE SEA E-26

by

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The marine microbial community frequently becomes unbalanced as a result of pollution. Millions of enteric bacteria and viruses are disposed daily into the sea from sewage outfalls posing a danger of disease. The flow of sewage and nutrient-rich run-off water also frequently results in the development of algal blooms in offshore waters. The rôle of the native marine microflora in the destruction of these microbial pollutants will be discussed. A direct relationship has been found between the size of the indigenous bacterial population and the rate of destruction of Escherichia coli in natural sea water. The antagonistic microorganisms have been isolated and will be described in detail. The processes controlling destruction of viruses in the sea have also been studied in this laboratory. A portion of the native microflora is involved in the inactivation, together with a chemical component of the sea water. However, the virus is frequently protected from both of these inactivation processes by adsorption to microbial surfaces. The native marine microflora controls the algal population. A group of microorganisms has been isolated which are capable of enzymatically degrading algae in the sea. Evidence has been obtained which indicates that these marine microorganisms are most active when the productivity has reached a peak. The antagonists serve to destroy algal communities in which a nutrient has become limiting and the physiological activity has become weak. The possibility of using the insight gained into these marine self-purification processes for more advanced pollution control will be discussed.

FILTER FEEDERS IN THE MARINE ENVIRONMENT: THEIR POSITIVE AND NEGATIVE INFLUENCE ON THE HEALTHINESS OF POLLUTED BEACHES E-27

by

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Many organisms feed on bacteria and yet do away with them. Whether this is due simply to the passing of such bacteria through the intestinal canal or to their actual use and destruction as food, this phenomenon leads to purification of the water. This action is extremely pronounced in certain recognized filter feeders (molluscs, chiones, salpas, amphioxi, sponges, etc.) and in limivorous organisms which swallow daily a large quantity of bacteria-rich mud. Such preying is examined from the qualitative and quantitative standpoints using bacteria marked with radio-isotopes or fluorochromes; signal results have been obtained with fairly simple techniques.

Lysis of the bacteria ingested (and, yet, their destruction) is possible in certain predators, either directly by the action of digestive enzymes or indirectly by the action of amebocytes; some bacteria, on the other hand, often survive for a long time in edible molluscs. Nevertheless, filter feeders may be useful in keeping water safe if ingested pathogenic bacteria do not return to man through the various links in the foodchain; however, they may be extraordinarily harmful (as true concentrators) if they are used by him for food purposes.

Research was subsidized by the Sub-Committee for Oceanographic Research, North Atlantic Treaty Organization (NATO).

LYSIS IN THE SELF-PURIFICATION OF SEA WATER

E-28

by

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Very recently two new groups of organisms, which are perhaps important in the self-purification of the sea, have been reported in external environments, namely, the Bdellovibrios bacteriovorus and lytic bacteria:

1. The Bdellovibrious (discovered in 1962) have been isolated in sea waters, especially along the coasts, in fresh water and sewage and on the soil; in the laboratory they are capable of lysing a large number of bacteria and of purifying polluted water; the explanation for this action very probably also lies in the external environment.

2. The lytic bacteria strains, which have been known for a long time (since 1907), were only isolated by us and other research workers almost simultaneously in 1969. They have been isolated in such great numbers in the marine environment and have shown themselves so active in the laboratory that it is to them that the bactericidal power of sea water - the cause of which is still debated - can be attributed.

The technique of isolation and the quantitative definition of these organisms is very simple and will be given in detail; their frequency, particularly in the polluted waters of the Bay of Naples, will be adequately documented.

Research was subsidized by the National Committee for Research, Water Research Institute.

RADIOACTIVE, METALLIC AND BACTERIAL POLLUTANTS IN THE SCHELDE ESTUARY AND ON THE BELGIAN COAST

E-29

by

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This paper puts forward an historical basis for, together with information available in various fields pertaining to, radioactive, metallic and bacterial pollution on the Belgian coasts of the North Sea and in the Schelde estuary. The Institute has carried out a systematic study of the various types of pollution in its coastal waters, in the estuary and in sediments. New techniques for taking, handling, preparing and analyzing samples have been developed in the Institute's laboratories and the results are presented in this note with objective criticism of the difficulties encountered from sampling to interpretation of the findings.

The purpose of the studies is to obtain an accurate knowledge of the ecological environment along the Belgian coast and of the potential effects on public health, on destruction of the site and on the biology of sea waters and, in particular, on the effects of human consumption of sea foods. The correlation between the various types of pollution and phosphate content and salinity of the waters has been attempted. The phenomena of precipitation and sedimentation at points where polluted fresh water is introduced into the marine environment have also been examined.

STUDY OF A EUTROPHICATED MARINE BASIN E-30

by

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Bedford Basin, Nova Scotia, has an area of 17 km^2, a maximum depth of 70 m and a sill depth of 20 m. The upper layer is exchanged continually with the open sea, the bottom water infrequently. The basin receives untreated sewage from 30,000 people. Compared with an unenriched embayment 40 km away, nutrient concentrations are three times higher, chlorophyll is ten times higher and primary productivity per unit chlorophyll is three times higher in Bedford Basin. There are important differences also in the species composition of the phytoplankton, zooplankton, epibenthic and benthic communities in the two embayments.

A DISCUSSION OF THE RESULTS OF ACUTE TOXICITY TESTS WITH MARINE ORGANISMS USING A STANDARD METHOD E-31

by

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In this paper, the author presents the results of toxicity tests with a variety of substances, using a standard method. The various classes of compounds studied include insecticides, herbicides, metals, detergents and oil dispersants. The results and their accuracy are discussed in terms of the chemical and physical nature of the materials tested and the testing method. For comparison purposes, some results are included of tests using larvae and flagellates. A few of the LC_{50} values given are also considered in the light of results of a number of avoidance reaction behavioural tests.

POSSIBLE DANGERS OF MARINE POLLUTION AS A RESULT OF MINING OPERATIONS FOR METAL ORES E-32

by

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The ever-increasing demands of modern technology for such basic raw materials as sand, cement and metals are now resulting in the exploitation of resources previously considered to be uneconomic. Sources at present utilized already involve mining operations, and fears have been expressed as to the possible dangers of marine pollution. In this paper, the author considers a number of metals and the possible dangers of the exploitation of their ores on the sea bed. Each metal is considered individually and the hazards to both marine animals and man are discussed.

TOXICITY-TESTING WITH PARTICULAR REFERENCE TO OIL-REMOVING MATERIALS AND HEAVY METALS

E-33

by

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This paper is intended as an introduction to the problems involved in toxicity-testing. Particular attention is paid to the toxicity-testing of heavy metals and oil-removing chemicals, and their modes of entry to the sea are briefly discussed. However, the types of apparatus which can be used in general toxicity-testing, using marine animals, are considered in detail, the disadvantages and advantages of the various methods are discussed and suggestions are made concerning the suitability of particular methods for particular materials. The value of using a variety of organisms and the differences in susceptibility of different stages of development in particular animals are also considered.

POTENTIAL HAZARDS FROM RADIOACTIVE POLLUTION OF THE ESTUARY

E-34

by

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Among man's aquatic resources, estuaries are probably the most susceptible to potential damage from pollution by various waste materials including radioactivity. Of the total fisheries harvested in the United States, more than 70% of the species spend part of their life cycles in estuarine waters, which may receive radioactive materials from a number of sources. In addition to radioactivity originating from fallout and from nuclear reactors occasionally located within the estuaries, there also can be an influx of radioactivity from river drainage basins. There is always a possibility that nuclear-powered ships, through accidents, may release large amounts of radioactivity in the estuary. Thus, it appears that man's most productive aquatic resources are subject to the most serious threats by his own advanced technology.

In order to evaluate the effects of radioactivity in estuaries, we have conducted both laboratory and field experiments on elemental cycling and on biological effects of radiation on aquatic organisms. Results from these experiments indicate that much of the radioactivity reaching the estuary would become associated with the biota and sediments. Pathways of some of these radionuclides have been traced in the laboratory through several trophic levels from phytoplankton to fish. Sediments were shown to act as reservoirs for both the stable and radioactive isotopes of Mn, Fe, and Zn. These elements once trapped within the estuary may then be accumulated by marine organisms, which would thus receive doses of radiation from internally deposited radionuclides as well as from radionuclides present in the surrounding water and sediment. Finally, we have investigated the biological effects of radiation as an environmental factor and have demonstrated that radiation sensitivities vary with changes in temperature and salinity.

DISSOLVED OXYGEN AS AN INDICATOR OF WATER POLLUTION IN EGYPTIAN BRACKISH-WATER LAKES

E-35

by

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Seasonal variations of oxygen in Lake Mariut, a shallow brackish-water basin adjoining the Mediterranean coast near Alexandria, Egypt, range between 0 and 20.31 mg/l. Dissolved oxygen in Nozha-Hydrodrome, which was separated artificially from Lake Mariut, ranges between 5.58 and 10.79 mg/l. This "daughter" lake receives only unmodified Nile water, whereas Lake Mariut receives industrial and domestic wastes which make its content of organic matter higher than that found in the Hydrodrome.

In Lake Mariut, dissolved oxygen is mainly consumed through the oxidation of these high amounts of organic matter. During the whole period of investigation, from January 1969 to January 1970, oxygen consumption was very high at certain stations, where its complete depletion was observed and the odour of hydrogen sulphide prevalent. The industrial wastes introduce also into the lake different toxic substances which have a harmful effect on fishes. The total fish production has decreased from 9,977,815 kg in 1961 to 1,868,600 kg in 1967. Such decrease in fish production is mainly due to lake pollution.

Various drains also flow into Lake Mariut. The Mex pumps discharge surplus water from the lake into the sea, in order to maintain its water at about 2.8 m BSL. The rate of mixing polluted lake water with sea water and the effect of the resulting marine pollution on the Mediterranean coast near Alexandria is another problem for further studies.

POLLUTION AND BENTHONIC FORAMINIFERA SPECIES DIVERSITY IN LONG ISLAND SOUND

E-36

by

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Bottom water and sediments were sampled at 47 stations in western Long Island Sound. The concentrations of nitrates and total phosphates in bottom waters, and of coliform bacteria in surface waters, are relatively higher than average at the western end of the Sound. Specimens of Elphidium clavatum, E. incertum "complex", and Bucella frigida are among the most abundant species of Foraminifera in both the living and the total populations. Generally, the percentage of living Eggerella advena and Ammonia beccarii in the living population show a direct relationship with phosphate and nitrate concentrations while the number of living species, the number of dead genera, the percentage of living Bucella frigida, and the number of Foraminifera per gram of sediment show an inverse association with phosphate concentration.

Geographic analysis shows a decrease in the number of living species in western Long Island Sound. Higher percentage of living Eggerella advena occur in the northern half of the Sound and may reflect increased nutrient supply available from several large rivers that empty into the Sound along its north shore. The percentage of living Eggerella advena is also higher at the mouths of Oyster and Northport Bays both of which serve as harbours for large numbers of pleasure craft. Common nearshore benthonic species such as Quinqueloculina seminulum, Q. seminulum var. jugosa, Q. subrotunda, Eggerella advena, Pseudopolymorphina novangliae, and Discorbis columbiensis are absent or rare at the extreme western end of Long Island Sound. Present distribution of certain species differs significantly from that reflected in core samples.

The proximity of marsh areas (adjacent to Long Island Sound) to pollution sources appears to be reflected by a decrease in the relative percentage of living Elphidium margaritaceum, an increase in the relative percentage of Elphidium tisburyense and Miliammina fusca, the absence of Reophax curtus, Textularia cf. tenuissima, Triloculina sp., and Tiphotrocha comprimata.

ON NITROGEN COMPOUNDS IN THE BALTIC E-37

by

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During 1969 an investigation was carried out in the Baltic on nitrate, nitrite, ammonia, total nitrogen at a total of 26 stations and on hydroxylamine in the stagnant basins. Parallel measurements of primary production were also carried out. When the investigation started, stagnation, which is caused periodically in the Baltic depending on the amount of inflow through the sill, prevailed in the upper half of the Baltic proper including the Gulf of Finland. Under stagnant conditions the nitrate was totally reduced to ammonia, the completeness of the process could be judged from the absence of intermediate products of nitrate and sulphate reductions, hydroxylamine and thiosulphate, in the hydrogen sulphide-bearing waters.

After the storms in September 1969, a large volume of saltier water flowed in, lifting stagnant waters upwards. Long and short-time variations of this change were studied at Gotland Deep, a station in the eastern Baltic. A nitrate minimum and an ammonia maximum was observed at an intermediate depth, in which daily variations clearly showed the amount of inflow into the basin.

In the surface layers during the peak period of production, nitrate disappeared while a trace of phosphate was still left. This confirms that in the Baltic nitrate limits production. In the southern Baltic during late autumn some production was measured, which may have been caused by pollution. Similar conditions prevailed in the interior of the Gulf of Finland, where during all seasons primary production was the highest. Since there was no secondary bloom in the northern Baltic, this may have been evidence of pollution in the Gulf.

Total nitrogen measurements indicate that in the Baltic a great part of the organic nitrogen comes from river humus. Unlike the open sea, total nitrogen here is mainly an organic fraction, which is partly due to the humus content and in part due to stagnation. From the amount of accumulated nitrogen compounds under stagnation, it can be calculated that when this stagnant water is raised to the surface it fertilizes the surrounding water to such an extent that plant life in the otherwise nutrient-starved Baltic can be maintained.

VIRUS INACTIVATION IN THE MARINE ENVIRONMENT E-38

by

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Sea-water samples from points along the Mediterranean and Red Sea coasts were repeatedly shown to possess virus inactivation capability. Polio-type 1 virus, seeded in sea-water samples held at 22°C, was reduced in titre by 4 to 6 logs in seven days while control samples of sea water heated to 90°C for 1 h prior to the seeding of virus showed only a 1 log reduction in titre under parallel conditions. Our studies have shown that the marine virus inactivation capability is heat labile and ether sensitive. It is apparently removed from sea-water samples by filtration through membrane filters, having 0.3 micron pore size.

Samples of coastal waters polluted with sewage appear more active than relatively unpolluted samples. Stimulation of the marine biosphere by higher nutrient levels resulting from sewage disposal appears to be a possible explanation. Certain evidence gained from laboratory studies seemsto support this hypothesis. These studies show that the onset of the logarithmic rate of virus inactivation in sea-water samples coincides with the point of maximum growth of marine bacteria. This relationship may not be coincidental. The rate of virus inactivation has been shown to increase with temperature.

A number of marine bacteria isolated from samples taken from the Mediterranean and the Red Sea have in pure culture demonstrated virus inactivation capability similar to that found in natural sea-water samples. Details as to the nature of this phenomenon will be reported upon. In field studies, enteroviruses were detected routinely in polluted coastal water with a new technique developed for concentrating and enumerating viruses in large samples of water. These, together with laboratory studies, point to a lower rate of virus inactivation in the marine environment than that of coliform bacteria. The T_{90} for coliforms was found to vary between 1-3 h while polio-type 1 virus concentrations were reduced by 90% only after 24 h in sea water, thus indicating that the inactivation of viruses in the marine environment might play only a minor rôle in protecting bathing beaches exposed to sewage pollution.

NATURE AND EFFECTS OF A KEROSENE-LIKE TAINT IN MULLET (Mugil cephalus) E-39

by

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A taint resembling kerosene is present in mullet (Mugil cephalus) caught near Brisbane, Australia, and in some other fish caught from waters close to oil refineries and port facilities. Investigations have shown this taint to be different from the "petroleum" taint sometimes present in cod (Gadus morhua) and chum salmon (Oncorhynchus keta) and caused by the decomposition of dimethyl-B-propiothetin to dimethysulphide. The kerosene-like taint is removed from the body tissue of the fish by extraction with fat solvents and is associated with the hydrocarbon fraction of the lipid.

The tainted fish examined showed a fatty infiltration of the livers and a higher lipid content in the fillets than those of untainted fish. A lower proportion of C16 and a higher proportion of C18 fatty acids was observed in the tainted fish than in the lipid obtained from fillets and liver of untainted fish.

The extraction of volatiles by vacuum sublimation and subsequent concentration of the sublimate yielded 2.7 ml of volatile oil from 25 kg of tainted fish and about 10 µl from the untainted fish. Gas liquid chromatography (GLC) of the volatile oil and a commercial sample of kerosene established a close qualitative and quantitative similarity of the major components and similarity of the odour descriptions assigned to peaks of comparable retention time. Infra-red and proton magnetic resonance spectra confirmed the compositional similarity of the two materials and indicated that they comprised mainly paraffinic hydrocarbons with a small content of aromatic components. The identical mass spectra obtained from trapped material corresponding to major peaks possessing kerosene-like odour descriptions and similar retention times on a capillary GLC column, fully established the identity of some of the major components contributing to odour of the two materials.

The results are discussed in relation to pollution caused by the release of petroleum hydrocarbons, their entry into fish tissues and their effect on fish caught from polluted marine environments.

PHYSIOLOGICAL CHANGES EXPERIENCED BY PACIFIC SALMON MIGRATING THROUGH A POLLUTED URBAN ESTUARY

E-40

by

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The Duwamish Waterway is a sewage-polluted estuary inside the city limits of Seattle, Washington, U.S.A., through which coho and chinook salmon (Oncorhynchus kisutch, and O. tshawytscha) migrate each autumn to reach their spawning grounds in upper parts of the Green River which empties into the estuary. The arrival of salmon at the mouth of the estuary coincides with the low river flows and low levels of dissolved oxygen (DO) found in late summer. Successful passage through the estuary usually occurs during the first autumn rainfall.

Until rainfall occurs, salmon seem to penetrate as far as possible up the estuary as they are able and stop at the point where their swimming stamina equals the water velocity. We studied the physiological condition of salmon by performing experiments aboard a floating laboratory anchored at the downstream edge of the region of lowest DO (2-4 ppm) and found that:

1. Blood lactate levels were 2-5 times normal and that significant amounts of lactate were excreted, representing a serious energy loss to the fish.

2. Oxygen consumption and the efficiency of removing oxygen from the waters were reduced.

3. Swimming stamina was reduced and, even after resting in aerated water, was insufficient to enable the fish to pass through the area of low DO into the river above the estuary before becoming completed fatigued.

4. The concentration of ammonia in the blood was less than normal during low DO.

5. Several hematological changes occurred.

BIOCOENOLOGICAL METHODS FOR ASSESSMENTS OF MARINE POLLUTION AND PROBLEMS OF INDICATOR SPECIES

E-41

by

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A number of scientists, including the author, are trying to apply an analogous methodology, similar to the saprobic system with indicator-organisms in fresh-water ecosystems, for the detection and the evaluation of pollution in marine environments. The results of these efforts are rather discouraging, showing this methodology as inadequate or perhaps leading to wrong conclusions, because of particular reasons which will be discussed in this contribution.

The application of detailed analyses of communities within polluted areas will be interpreted as adequate but significant only within limits of the organic pollution, and this only in the cases of high rates, yet for slight organic or toxic industrial pollution this methodology does not seem to be satisfactory. It was also shown that this methodology represents, if we take all taxonomic work required into consideration, a very difficult and long-lasting operation, and is therefore rather uneconomical and impractical, and because

of that, another more simple methodology was introduced and statistically tested by the author. For this purpose the principle of the decreasing species-diversity and the increasing specimen-abundancy in polluted ecosystems was used to establish the pollution detection method of the species/area and diversity/abundance curves for graphs and the diversity-indices for computed representations. The principles and the technique of this methodology will be presented and discussed on the basis of a number of tested examples, enclosed in this contribution.

POLYNUCLEAR AROMATIC HYDROCARBON POLLUTION OF THE MARINE ENVIRONMENT E-42

by

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The presence of polynuclear aromatic hydrocarbons (PAH) in general, and 3,4-benzpyrene (BP) in particular, in estuaries and coastal waters has been by now well established. BP, a well recognized carcinogenic substance, has been found in sediments, flora and fauna of polluted as well as non-polluted marine waters. PAH are considered to be ingested by the fauna from the surrounding waters, while their presence in the flora may partially result from endogenic synthesis. Because of their demonstrated presence in food, air and water consumed by man, PAH must be considered a potential health hazard to man. Therefore, their excess presence due to pollution in coastal water food resources is undesirable.

THE INFLUENCE OF TIDES, WAVES AND OTHER FACTORS ON DIFFUSION RATES IN MARINE AND COASTAL SITUATIONS E-43

by

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Measurements of diffusion rates in both marine and near coastal situations are described and compared. Each of the coastal surveys was in connection with a particular pollutant dispersal problem and the possible effect on local fisheries. The measurement of diffusion rates involved the dye tracer Rhodamine-B and, in most cases, a moored array of recording current meters was also used. Geographically the situations dealt with range from open North Sea conditions more than 100 mi from the nearest land to positions within a mile of the shore. A range of wind and sea states is also covered up to full gale and heavy swell conditions.

The diffusion results are discussed in the light of the turbulence levels suggested by spectral analysis of the current meter records and the relative influence of tidal action, swell and other factors on the rates of diffusion.

CHEMICAL AND PHYSICAL INVESTIGATIONS IN THE GERMAN BIGHT ON MARINE POLLUTION CAUSED BY WASTES OF A TiO_2 FACTORY

E-44

by

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Since May 1969, the wastes of a TiO_2 factory, situated near Bremerhaven, have been deposited in the German Bight. The disposal area is a rectangle of 12 mi^2 with the centre 14 n mi northwest of Heligoland. In this area the water is 25 to 28 m deep. The waste water of the TiO_2 factory contains 10% sulphuric acid and about 14% ferrous sulphate. The other constituents are of minor importance. 1,800 t per day of these wastes are discharged in the disposal area by a special tanker. In order to achieve a quick dilution the wastes are introduced into the propeller water of the tanker when running at about 8 kn. The unloading of the tanker takes 1-2 h.

The most important physical processes and chemical changes in the sea water and on the sea bottom were studied by the German research vessel GAUSS in May and October/November 1969. The main results were:

1. The initial dilution of the waste water by the propeller of the tanker was about 1:1,000.

2. The first phase of the secondary dilution of the propeller water by unpolluted sea water proceeded very rapidly. 1-2 h after the discharge, the dilution factor was about 10. Later on the factor was much smaller.

3. The pH reached its minimum value immediately after the release of the wastes. 4 min after the release, the pH in the centre of the propeller water was about 6.0. The O_2 deficit in the centre of the propeller water at no time exceeded 30%. Some hours after the discharge the dilution had proceeded to such an extent that the pH and the O_2 concentration had reached nearly their normal values.

4. During the first hours after the release the wastes did not penetrate to the sea bottom. As the pH and the O_2 concentration had reached nearly their normal values already within some hours after the release, there was at no time a significant decrease of the pH and the O_2 concentration near the sea bottom.

5. The analyses of the bottom samples taken in November 1969 - that means $5\frac{1}{2}$ months after the beginning of the waste disposal - have not yet been finished, but there seems to be a certain increase of the Fe concentration in the upper layer of the sediment.

6. $5\frac{1}{2}$ months after the beginning of the waste disposal the quantity of suspended ferric hydroxide was relatively small. The area with a remarkable increase of the Fe concentration was about 200 mi^2. The highest concentration which was found in this area amounted to 500 µg Fe per litre.

THE TOXICITY OF OIL-SPILL DISPERSANTS TO THE EMBRYOS AND LARVAE OF SOME MARINE FISH

E-45

by

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The factors affecting the toxicity of several oil-spill dispersants to the embryos and larvae of six species of marine fish have been examined. The main factors influencing the toxicity of a dispersant are the type and aromatic content of the solvent. Ageing of the test solutions leads to a marked decrease in toxicity, but temperature and salinity have little or no influence. For all dispersants differences of susceptibility between species are less than differences at different ages within a species. The larvae of all species show a similar susceptibility when newly hatched, but the embryos (within the chorion) are more resistant. Susceptibility increases during the yolk sac stage until the larvae have become established feeders, when resistance increases up to metamorphosis.

More sensitive indicators than survival have been designed to determine the presence, degree, and persistence of sublethal toxication. Yolk sac larvae were reared to metamorphosis after sublethal dosing. No differences in any ten of the parameters measured were found between control and experimental populations. Feeding experiments have shown that in the presence of sublethal concentrations the ability of the larvae to capture food organisms is impaired, but after returning to unpolluted water they recover completely. Measurements of activity show similar results, while preliminary experiments with a small fluvarium indicate that the older larvae at least can avoid lethal concentrations of dispersants.

INVESTIGATION AND PREDICTION OF DISPERSION OF POLLUTANTS IN THE SEA WITH HYDRODYNAMICAL NUMERICAL (HN) MODELS

E-46

by

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Experimental investigation of transport and diffusion of pollutants in estuaries and coastal waters is expensive and time-consuming. However, by using large computers, Hydrodynamical Numerical models can be applied to pollution problems at any location with proper specification of depth distribution, boundary conditions (tides, fresh-water inflow, wind and pollution source).

The basic hydrodynamical formulae, the finite difference form of W. Hansen and the computer programme are given for computation of synoptic distribution and behaviour of currents and diffusion in estuaries and coastal waters. The grid size in the examples shown varies from 1 km to 18 km and the time step from 12 sec to 300 sec. The transport is computed at desired locations from net tidal and wind current considerations. Thermohaline current component can also be included if desired. Some special boundary problems and their treatment are described.

Included in the model is the Joseph-Sendner diffusion approach in modified form, which yields the areal distribution of concentration at desired output times. It is shown that chemical, radiological and biological decay of pollutants can also be treated in numerical form in the same model. A few examples of the application of the model are shown and some verifications presented. A brief description of a more advanced multi-layer model and some examples of results are also given.

SALMONELLAE AND BACTERIAL INDICATOR ORGANISMS IN POLLUTED COASTAL WATER AND THEIR HYGIENIC SIGNIFICANCE

E-47

by

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A study of the dispersion and dieaway patterns of microbial pollution in coastal waters was carried out during the summer and fall of 1968 and 1969, in an area adjacent to Tel Aviv, in which coliforms, salmonellae and enteroviruses were used as microbial pollution indicators. A new sensitive method for isolating salmonellae from large volumes of sea water was developed in 1968 and comparative studies were made with two other methods - "moore pads" suspended in sea water for 1-2 days and filtration through membrane filters - for their efficiency in detecting salmonellae. The new method, based on concentration of the enrichment medium instead of the sample, is less tedious and time-consuming than the other methods, yet more efficient.

204 strains of salmonella, belonging to 35 serotypes (not including the various phage types) were isolated. 54 of them were isolated in 1968 by all these methods from 37 positive samples out of 115 tested (32.2% positives), while 150 were isolated in 1969, by the concentrated medium method alone, from 73 positive samples out of 91 examined (80%). In one single day, out of 22 samples taken at varying distances from the waste water outfall up to 2 km, showing various levels of pollution as indicated by the coliform counts, 20 were positive (91%) and from them 46 strains of salmonella belonging to 22 serotypes were isolated. In one case, where four 500 ml samples from the same place, each from a different depth, were inoculated, 10 strains belonging to 8 serotypes were isolated, half of them from the top layer.

The predominant serotypes isolated were S. paratyphi B. and S. paratyphi B var odense of various phage types. Other serotypes were isolated one to nine times. In a number of cases, salmonellae were detected in sea-water samples with a coliform density lower than 2,400 per 100 ml, which is considered as an acceptable standard for bathing water in some countries. The hygienic significance of these numerous salmonella isolations in coastal waters adjacent to public bathing beaches is evaluated in relation to physical dilution of the waste water and coliform index.

EXPERIMENTAL STUDIES OF HORIZONTAL DIFFUSION IN THE BLACK SEA COASTAL ZONE E-48

by

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Research work on turbulent diffusion is made up of various aspects of studies on self-purification of the sea from pollution and involves analyzing the transformation of sewage field or sewage flows. Complex research work is underway to estimate horizontal mixing and the rate of dilution in the sea.

1. Studies of diffusion by the "neighbour diffusivity" method (Richardson method). These indicate that the "4/3-law" is not universal and is seldom carried out in the coastal zone. The value of eddy diffusivity K depends on the scale of the diffusion phenomenon ℓ according to the relation $K \sim \ell^n$. Power index n for the scale of phenomenon up to 10 km is lower than 4/3 in most cases. However, the value n for "mesoprocesses" (scale 1-10 km) is 1.5 - 2 times as great as that for small processes (hundreds of metres).

Also discussed is the relationship between K and other determinative factors - current velocity and water density stratification. In terms of "Richardson diffusion", the following parameters were estimated:

(i) The extent of relative expansion of a non-stationary diffusion patch depending on the duration of diffusion and power index n.

(ii) The extent of relative expansion of a diffusion patch under stationary conditions depending on value n and other factors.

2. Studies of horizontal diffusion patches by aerophotography. The experiments were carried out in 1968-1969. The analysis of data on non-stationary diffusion patches obtained by aerophotography made it possible to determine: (1) the relationship between patches area S and the time t which is approximated by the expression $S \sim t^m$, (2) probable diffusion velocity ($\dot{P}$) according to Joseph and Sendner, and (3) values of small-scale diffusion coefficients. The data obtained indicate that the "4/3-law" is not carried out. The results obtained are discussed and compared with those by other investigators.

CURRENT BACTERIAL POLLUTION OF FRENCH OFFSHORE WATERS E-49

by

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The authors present a synthesis of the results of this inventory of fecal pollution germs in all French coastal waters. These bacteriological assays were performed on the Atlantic and English Channel coasts at rising and falling tide and in the Mediterranean, under various weather conditions. The sampling sites were chosen an average of 3,000 m apart and were used for one sampling near the shore and another further offshore perpendicular to the -5 bathymetric line. Analysis methods included the investigation and enumeration of coliforms bacilli, Escherichia coli and fecal Streptococci, as well as a total germ count.

The results of these bacteriological assays are presented as variables - first for each site and second of the length of the shoreline - under various hydrological and meteorological conditions. At the same time, a conspectus is given of the dynamics of coastal waters which cause the dissemination of pollutants and which enable the breakdown of such telluric pollution to be explained in terms of contamination sources (waste water outlets, estuaries, port complexes, etc).

In the Mediterranean a study has also been made of the distribution of water masses by the investigation of surface isotherms and isohalines. On the basis of these various data, it is possible to determine general laws relating to the diffusion of bacterial pollution, and construct a mathematical model allowing forward studies to be performed on the control of this type of pollution.

UTILIZATION OF THE TROPHODYNAMIC CHAIN IN THE STUDY OF THE TOXICITY OF CHEMICALLY-POLLUTED WASTE WATER

E-50

by

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The authors have performed a general study of chemically-polluted waste along the coasts of France. They examined the effects of such waste on a marine biological chain (phytoplankton, zooplankton, fish and the higher mammals) and in this way determined, first the toxicity thresholds (lethal doses) of each type of polluted water with respect to the constituents of a marine biological chain and second by following the successive passages between the various levels of this biological chain, the transmitted or induced toxicity due to nutrient concentration factors. By this method, which is employed for purposes of comparison with conventional techniques for the chemical measurement of the constituents of these waste waters, it is possible to identify more readily the influence of such pollution on the elements of the marine environment and the toxic effects which it may have on the final consumer in the trophodynamic chain.

The studies covered over a hundred types of industrial wastes and included testing effluent from the petrochemical industry, wood chemistry, the metallurgical, plastics and ceramics industries, from cement works, canneries, etc. The results allow a more realistic approach to the dangers to the marine environment and its nutritional utilization as a result of pollution due to chemically-polluted water.

METHOD OF APPROACH FOR THE EVALUATION OF CHEMICAL POLLUTION LEVELS IN MARINE ENVIRONMENTS AND MARINE FOOD CHAINS

E-51

by

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A simple mathematical model has been proposed for the evaluation of transfers of radioactive pollution to marine food chains: if D is the dose of radiation delivered to the organisms, Q the ingested quantity of each food vector, F the transfer factor of the radioelement from the environment to the organism and x the water contamination level:

$$D = \sum D\,(Q, F, x)$$

the sum $\sum$ being extended to cover food vectors as a whole and all the radioelements considered. For man, observance of protection standards demands $D \leqslant D_1$.

This study suggests the possibility of proposing a very similar model for transfers of chemical pollution in the different oceanic trophic levels: if D' is the quantity of pollutant incorporated by an organism or one of its organs whose contamination depends on that of the water, Q' the quantity of each food vector of the pollutant, F' the transfer factor and x' the pollution level of the environment, the following relationship will result:

$$D' = \sum D' (Q', F', x'$$

$D' \leqslant D'_1$ being required in order that the integrity of the environment, of living organisms and of human health may be safeguarded.

Further a list can be made of the parameters on which transfers depend. Its application can clarify concepts relative to critical ecological level, permitted concentration in water, foods and critical diet, thus allowing identification of priority studies for the protection of the marine environment and human health.

SUBTLE EFFECTS OF POLLUTION ON INSHORE TROPICAL PLANKTON E-52

by

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Domestic sewage and stream runoff supply supplementary nutrients to Kaneohe Bay, Hawaii - primarily to the south sector. In the most productive (south) sector of the bay, changes have occurred in the plankton over the past few years that indicate a trend toward eutrophication, decreasing diversity, altered eco-system structure, and decreasing plankton population stability with attendant violent fluctuations in standing stocks of a few species. None of these changes are clearly desirable, some are clearly undesirable.

Knowledge of the present state of the bay provides a model to predict the specific changes that may occur in the less productive parts of the bay if the trend toward eutrophication continues. There is a cline from higher primary and secondary productivity in the south sector to lower productivity in the north sector. Biotic diversity and, apparently, stability are inversely related to productivity in the bay. The water current system will continue to maintain differences between sectors of the bay even if the overall plankton community becomes altered by pollution. But the relatively less productive areas can be expected to regress through a series of stages that are analogous or homologous to the present conditions in the relatively more productive area.

PRIMARY PRODUCTION AND DIEL OXYGEN MEASUREMENTS OF THE PATUXENT ESTUARY, MARYLAND, 1963 THROUGH 1969 E-53

by

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The Patuxent Estuary, one of the tributaries of the Chesapeake Bay estuarine system, has been under intensive biological, chemical, and physical investigation by state, federal, and private agencies since 1962. The investigation has been principally concerned with the

effects of heat addition from a steam electric station, but the estuary has also received an increasing load of domestic pollution and an increasing amount of water diversion in its upper reaches.

From 1963 through 1969, the authors operated a continuous recording, 8-parameter, water-quality monitoring system located in the upper estuary. The system measured surface and bottom temperature, tide stage, conductivity, dissolved oxygen, turbidity, wind velocity, and wind direction. Data collected served as a reference for spot measurements made elsewhere in the estuary. Over the period of record, a pronounced change occurred in the diel oxygen record, particularly during the months of June, July, and August. During the first year of record, oxygen varied from 3.6 mg/l to 15.0 mg/l with saturation ranging from 60 to 130%. During the last years of record, oxygen varied from 2.3 to 16.5 mg/l and from 30 to 184% saturation.

Hourly values of temperature, conductivity, and dissolved oxygen have been placed on IBM punchcards, and a computer programme has been adapted to compute salinity, percent saturation of oxygen, gross primary production, respiration, net primary production, and ratios of gross production versus respiration. A typical day in August 1969 showed a gross production of 19.5 g/oxygen/m^2/day, 22.9 g/oxygen/m^2/day respiration, with no net production, and a P/R ratio of 0.85.

Analysis of diel oxygen curves over long periods of time reveal much about interrelationships between the biota, water quality, and the physical factors affecting both. These data add significantly to an understanding of the estuarine environment and, over the 6-year period, have recorded a change from oligotrophic to eutrophic conditions in the upper Patuxent Estuary. Spot measurements by others of nutrients, chlorophyll "a", and carbon-^{14} productivity measurements support these findings.

LEGAL ASPECTS OF SEA WATER POLLUTION CONTROL E-54

by

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Since 1954 the International Law Association, a non-governmental organization of international jurists, established in 1879 has been occupied with legal aspects of water pollution control. In 1966 at its Helsinki Conference the Association adopted a set of rules on the uses of Waters of International Rivers, part of which deals with pollution control of surface waters. In 1967 a sub-committee of the Association took up the study of problems relating to pollution control of maritime waters.

As a first step provisional rules have been elaborated as to interstate liability for damages caused by "continental pollution", viz. pollution resulting from human activities taking place within the territorial jurisdiction of the state or on its continental shelf. Following the establishment of rules on "continental pollution" the Committee will study similar rules concerning pollution control of the high seas; for such rules some tentative suggestions have been made.

PLANKTON IN THE NORTH ATLANTIC : AN EXAMPLE OF THE PROBLEMS OF ANALYSING VARIABILITY IN THE ENVIRONMENT

E-55

by

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Variability induced by pollution must be detected and measured against the spectrum of natural variation. It will be necessary to intensify research on variability in the seas and to link it more closely with studies of the atmosphere.

The problems are exemplified by the Continuous Plankton Recorder survey of the North Atlantic and North Sea. During the past 22 years, over a part of the area, there has been a progressive decline in the abundance of many species and in the biomass of the zooplankton; the annual season of biological activity, judged by standing stocks at the sampling depth of 10 m, appears to have shortened.

It is difficult to relate these changes to causal factors because of the inadequacy of environmental observations. It is not clear whether changes in sea temperature, or trends in climate and solar radiation, are cyclic or continuing trends, the result of increasing turbidity of the atmosphere or of variations in the output of the sun. Experimental work has shown that pesticide residues may depress the rate of photosynthesis but there are no long-term data for pesticides in the open ocean. We do not know whether there have been changes in the vertical distribution of plankton or in the rates of production and turnover. In the absence of comparable surveys of the benthos and coastal regions we do not know whether events in the plankton reflect a general trend in marine communities.

Technical developments in, for example, computers and field instrumentation are providing the opportunity to solve many of these difficulties.

NUTRIENT AND POLLUTANT CONCENTRATIONS AS DETERMINANTS IN ALGAL GROWTH RATES

E-56

by

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The purpose of this study is to determine the growth rate of algae over a several-day period, in the presence of various pollutants. Suspensions containing approximately one part per million of cells are provided with varying concentrations of nutrients and pollutants, and exposed in small vials to a constant light intensity of approximately 500 ft candles. The vials are inserted periodically into a fluorometer to measure changes in the fluorescence of the cells.

Certain pollutants exert a considerably more toxic effect in combinations than by themselves, e.g., oil and DDT. The most significant finding in regard to the effects of pollutants in natural waters, is that many cultures may be inhibited greatly during the first day of exposure to a toxicant but recover on succeeding days. The extent of inhibition or recovery is governed largely by the nutrient concentrations provided by the cells.

Care must be exercised in assessing the effects of surface-active agents on algal growth rates because the surface/volume ratio of the test vial used is a factor; toxicity is inversely related to the surface/volume ratio.

The implications of the results obtained, in terms of the revitalization of polluted waterways, will be discussed.

STUDIES ON BIO-DEGRADATION OF ORGANIC MATERIALS IN THE DEEP-SEA

E-57

by

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Recent *in situ* experiments on microbial degradation involved depositing samples of complex and defined organic substrates on or near the ocean floor in depths of 2000 to 5000 m. Some of the sample containers were equipped with a device for *in situ* inoculation by hydrostatic pressure. Other samples were pre-inoculated either with mixed bacterial populations obtained from surface waters or with pure cultures of known metabolic properties, including psychrophilic strains of bacteria isolated previously from the deep-sea. The test samples were exposed to the deep-sea environmental conditions for 2 to 6 months. The measurement of microbial activities included growth, ammonia production, incorporation of radioactive labelled organic carbon and the formation of labelled carbon dioxide.

These experiments indicate surprisingly low rates of microbial activities in the deep-sea compared with controls incubated at equal temperatures. There is no ready explanation for the observed phenomenon except for pressure effects in combination with restricted adaptive capabilities of the natural microbial population. Considered as a preserving effect of the deep-sea environmental conditions on the bio-degradability of organic materials, the phenomenon becomes of high practical interest. Accumulation of organic waste materials in the deep-sea in connection with slow but effective bottom currents might create dangerous situations. Detailed studies are underway for more accurate estimates of degradation rates and possible long-term effects on microbial enrichments in the deep-sea.

THE USE OF NUTRIENTS IN THE ENRICHMENT OF SOCKEYE SALMON NURSERY LAKES
A Preliminary Report

E-58

by

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The quantity of nutrients introduced into lakes from the carcasses of anadromous fish has been shown in some cases to be an appreciable fraction of the total nutrient budget in oligotrophic lakes. However, the relationship between nutrient enrichment of lakes by this process and the availability of food to young anadromous fish is complex. Continual depletion by the fishery of adult anadromous fish may have caused serious effects in lowering the natural fertility of certain nursery lakes. Artificial organic or inorganic nutrient enrichment of these lakes is being proposed, and preliminary studies on a large (51 km^2) sockeye salmon producing lake will be discussed with reference to the constructive use of "pollutants".

THE ACUTE EFFECTS OF HEATED EFFLUENTS ON THE COPEPOD *Acartia tonsa* FROM A SUB-TROPICAL BAY AND SOME PROBLEMS OF ASSESSMENT

E-59

by

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Most of the information concerning the effects of heated effluents on marine organisms has been derived from experience in north temperate waters. In the shallow mangrove-fringed bays and estuaries of south Florida (and many similar areas throughout the world) ambient summer maxima of 31 to 34°C are already dangerously close to the upper lethal level for many species. Since these temperatures may be maintained over several months, and be accompanied by extremes of salinity variation, the natural populations are already under severe stress. Furthermore, in highly developed areas, electrical demands are highest during the summer rather than the winter, increasing the effluent further above environmental ambient.

This paper describes the effects of combinations of extreme temperatures and salinities for a range of zooplankton in terms of standard 48 and 96 h tests, and the extent to which these change with seasonal acclimation. The short-term thermal effects of entrainment through the Power Generating Plant, involving rapid temperature rise, maintenance of the elevated temperature for 3 h during passage down an exit canal and subsequent rapid cooling by remixing, are also investigated. At full design capacity, the Plant will entrain the total volume of the enclosed bay system adjacent to which it stands every 14 days. The implication of this in terms of both the function of the zooplankton as a link in the food chain towards the commercial invertebrates and fish, and as an integral part of the life histories of most of these organisms, is discussed.

Emphasis is placed on the copepod *Acartia tonsa*, possibly the most important single zooplankton species in terms of biomass of coastal waters of the eastern United States.

WATERFRONT HOUSING DEVELOPMENTS - THEIR EFFECT ON THE ECOLOGY OF A TEXAS ESTUARINE AREA

E-60

by

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Studies were conducted during 1969 to compare the ecology of a natural estuarine area (marsh and bay) with the ecology of an adjacent estuarine area altered by channelization, bulkheading, and filling. In each area, hydrographic factors, fishes, crustaceans, and benthic macro-invertebrates were sampled periodically from March through October. Setting, growth, and mortality rates of juvenile oysters (*Crassostrea virginica*) were measured from February through October and phytoplankton productivity was determined from June through August.

Values of oxygen, nitrite, and Kjeldahl nitrogen were significantly higher in the natural area; total phosphorous was significantly higher in the altered area. Although 64 species of fishes and crustaceans were collected by trawl, 6 species comprised 88.8% of the total catch. *Brevoortia patronus*, *Anchoa mitchilli*, and *Micropogon undulatus* were most abundant in the altered area; *Penaeus aztecus*, *P. setiferus*, and *Leiostomus xanthurus* were most abundant in the natural area. The setting rate of oyster spat was 14 times, and the rate of growth of juvenile oysters was 1.8 times, greater in the natural than in the altered area. Oyster mortality was significantly greater in the altered area during the summer.

Gross production of phytoplankton in the surface waters averaged 2.24, 2.06, and 1.17 mg. carbon/l./day in the altered, marsh, and bay areas, respectively. In part of the altered area, extremely high phytoplankton production, which caused low dissolved oxygen, reduced the abundance of fishes and invertebrates in the summer.

EXPERIMENTS ON MICROBIOLOGICAL METHYLATION OF MERCURY (2+) ION BY MUD AND SLUDGE IN ANAEROBIC CONDITIONS

E-61

by

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Investigations were carried out on the formation of methyl mercury from inorganic mercury ion by four preparations (garden soil, bottom mud of a eutrophic lake, activated sludge, and incubating sludge, both from a sewage treatment plant) in anaerobic conditions using the tracer ^{203}Hg. No methyl mercury was formed during 34 days in these experiments. Methylation of 0.1% of the mercury added could have been detected.

The tragic mass poisonings by methyl mercury in fish of the local fish-consuming populations in Minamata and Niigata, Japan, between 1953-65 (Kurland et al., 1960; Irukayama, 1966; Ui, 1970) and the alarmingly high mercury contents of fish in many waters in Scandinavia (Johnels et al., 1967; Sjöblom and Häsänen, 1969), U.S.A. and Canada (Anonymous, 1970), have drawn wide attention to mercury as a pollutant of fresh and coastal waters.

A major problem in the mercury pollution of fish is the transformation of inorganic mercury to methyl mercury: in Scandinavia nearly 100% of the mercury in fish is in the form of methyl mercury, even in waters where all pollution has been in the form of inorganic or phenyl mercury (Westöö, 1966; Noren and Westöö, 1967).

THE INFLUENCE OF EFFLUENT FROM A PULP AND PAPER MILL ON THE BENTHIC FAUNA OF A SCOTTISH WEST COAST SEA LOCH

E-62

by

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Brief descriptions of the survey area and its environmental and faunal features are given. The characteristics of the effluent being discharged are described and its possible short-term and long-term effects on the system and its fauna are considered. The results of a 5 year monitoring survey of the macrobenthic fauna are briefly summarised. A general rise in the total organic content of the sediments has been observed but the levels at all sampling stations remain well below the maximum naturally occurring levels within the area. Considerable variations have been observed in the total standing crop of macrobenthic invertebrates over the 5 year period, but no consistent trends either of increase or decrease which could be attributed to the effects of the effluent have been noted. Fluctuations in the numbers of dominant species are compared spatially and temporally in an attempt to isolate a component of change attributable directly to the influence of effluent, but it is generally concluded that 3 years after the introduction of effluent into the system, the benthic ecology appears to have varied little from the conditions prevailing during the two preceding years.

MONITORING ORGANOCHLORINE CONTAMINATION OF THE MARINE ENVIRONMENT BY THE ANALYSIS OF RESIDUES IN SEALS

E-63

by

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Organochlorine compounds are accumulated in fatty tissues in increasing concentrations on passage through animal food chains, and relatively high levels of organochlorine pesticide contamination in seal blubber samples from both sides of the Atlantic and the Baltic have been reported in earlier papers. Analyses of such samples have been used to compare the levels of contamination of the marine environment by both the organochlorine pesticides and the polychlorinated biphenyls (PCBs), compounds widely used in industry. An improved analytical technique has made possible the separate determination of the two groups of compounds, avoiding the interference in the pesticide residue analyses previously caused by the PCBs.

The paper discusses the differences in contamination levels of dieldrin, DDT and its degradation products, and PCB compounds in various marine areas, in relation to their usage in the adjacent land areas. The problem of accurate assessment of PCB concentrations is outlined, and the relative proportions of PCB isomers in different areas are compared. It is suggested that some degradation of certain PCB isomers in commercial formulations must occur, but degradation of DDT appears to be less than in many other types of wildlife samples. Dieldrin concentrations are generally much lower than those of the DDT group, which approach 100 ppm on the Canadian coast, and PCB concentrations exceeding 100 ppm are found in samples from the coasts of Great Britain.

THE INFLUENCE OF CRUDE OILS ON FISH FRY

E-64

by

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Literature on the subject reveals oil pollution being a steadily increasing hazard to aquatic organisms during the past seven decades. A review of published information on the effect of crude oils and some of their products is given.

Recent experiments were carried out to study the effect of fresh crude oils of different origins (Venezuela, Iran, Libya) on eggs and larvae of herring, cod, and plaice. They were exposed to dispersions of fresh crude oils in water and to water containing dissolved crude oil compounds.

The registration included the mortality of eggs, hatching rates, larval abnormalities, and the survival time of larvae in the test water. The results show that the mortality of the eggs is proportional to the concentration of dissolved compounds if it exceeds a certain limit. The eggs are most heavily affected during the first 3 days of their development. Larvae are more sensitive to the same concentrations of dissolved compounds than the embryos are.

Dispersions have a much higher toxicity than the same amount of an oil film at the water surface. The toxicity of dispersions still increases when mixed with a dispersant even if the dispersant is untoxic at the concentration applied.

Further experiments showed that larvae seem not to be able to percept oil dispersions. They do not avoid the dispersions which have immediate effects on the primordial fin and the integument of the young larvae.

THE PLACE OF ECOLOGICAL MONITORING IN THE STUDY OF POLLUTION OF THE MARINE ENVIRONMENT

E-65

by

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The paper details the use of gross attributes of the "kelp forest" ecosystem, to monitor the inshore marine environment along two pollution gradients on the east coast of Britain. Data from two reference sites are also presented.

The main effects of pollution are shown to be: (1) Light attenuation by material in suspension reducing the productivity of the dominant algae and the potential of the ecosystem. (2) A reduction in the diversity and stability of the populations of invertebrates, which inhabit the holdfast of the kelp. This appears to be caused by an interaction of two main factors. Energy rich sewage, which allows suspension feeders to dominate the habitat, and some other factor, perhaps toxicoids, which cause violent fluctuations in the populations of the dominant organism. (3) Analysis of members of the food chain shows that levels of toxicoids are higher in the organisms from the polluted sites. No massive accumulation of toxicoids through the food chain was found pointing to either efficient regulatory mechanisms, or breakdown of the food chain itself.

The relevance of data from an *a postiori* monitoring system in answering the question "What constitutes pollution?" is discussed.

METHYLMERCURY: HALF-TIME OF ELIMINATION IN FLOUNDER, PIKE AND EEL

E-66

by

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^{203}Hg-labelled methylmercury, as the ionic form nitrate, and as a protein-bound form, was applied perorally, and as the ionic form, injected intramuscularly to three species of fish, flounder (*Pleuronectes flesus*), pike (*Esox lucius* L.) and eel (*Anguilla vulgaris*) and its rate of elimination was determined by "whole-body counting" the live fish for 100 days in a gamma spectrometer. Both forms of methylmercury gave for flounder and pike rather similar half-times, between 640 and 780 days, but intramuscular injection gave to flounder 1,200 ± 400 days. For eel, the proteinate gave perorally 910 days; the ionic form both perorally and intramuscularly 1,030 days.

EXCRETION RATE OF METHYL MERCURY IN THE SEAL (Pusa Hispida) E-67

by

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The excretion rate of methyl mercury in the ringed seal (Pusa hispida saimensis Nordg.) was determined using ^{203}Hg-labelled methyl mercury as a proteinbound preparation with peroral administration, and the whole body counting technique. During the first month the elimination was masked by an improvement of the measuring geometry, methyl mercury being translocated from stomach into fatty tissues on the surface of the animal. Between 100 to 153 days however, a straight line was obtained on a semi-logarithmic plot giving for the slow component of excretion a half-time of 500 days. About 45% of the dose given follows this excretion rate. Between 30 and 100 days a "fast component" is evident having a half-time of the order of 20 days, this value is approximate only because of the masking effect of the geometry change. This investigation was carried out because toxic levels of mercury were recently measured in the small relic population of ringed seal in Lake Saimaa, which is included in the IUNC list of animals requiring special protection.

MERCURY AS A HYDROSPHERIC POLLUTANT. I. ACCUMULATION AND EXCRETION OF $^{203}Hg\,Cl_2$ IN Tapes decussatus L. E-68

by

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Some aspects of mercury's metabolism in Tapes decussatus L., related to the potential hazard from mercury pollution of marine environment, are described. Mercury as ^{203}Hg was used in chloride form.

Mercury is rapidly accumulated by Tapes from sea water and within 1 day the animals contain 10 times more mercury per unit weight than their environment. During longer exposure the accumulation of mercury is considerably slowed down. The visceral organs contain more than half of the mercury accumulated during 14 days, while the muscles contain less than 2% of the total accumulated mercury.

The loss rate of the accumulated mercury does not depend on the duration of the animal's exposure to it, but is strongly dependent on the method of its entry. The retention of the accumulated mercury is the highest after it was introduced into Tapes by injection into foot muscle; only about 25% of the injected mercury is lost within 2 months, mostly in the first 6 days. The retention of mercury accumulated from sea water or through the food chain is not too strong and has an overall biological half-time of about 10 and 5 days respectively.

STUDY OF A MARINE SITE WITH RESPECT TO DISCHARGES OF RADIOACTIVE EFFLUENTS

E-69

by

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The discharge of radioactive effluents in the marine environment causes a potential risk of secondary irradiation of the populations due to the contamination of marine products and of their utilization for alimentary or other purposes. Definition of the limits of the discharges has to be taken from the studies and research concerning the transfers of radionucleides from their starting point until reaching man, through the components of the marine environment : water, sediments, living organisms. Research should also cover the eventual action of the radioactive substances on the biological equilibrium of the environment. Such studies have been undertaken by the Atomic Energy Commissariat, or under its direction, on the occasion of the opening at The Hague of a factory for treatment of irradiated combustibles. The authors describe the fields explored and the principal results obtained. They stress the importance of the physical-chemical state of the radionucleides in their evolution and their transfer to the marine environment.

Research which has been developed for the study of radioactive pollution of the marine environment could be extended, using an identical methodology and techniques, to the study of marine contaminations due to non-radioactive chemical pollutants.

STUDY OF MARINE POLLUTION BY ANIONIC DETERGENTS FROM SEWAGE OF THE CITY OF MARSEILLES

E-70

by

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Each day the dumping by the City of Marseilles of 500.000 m of sewage into the sea constitutes an input of anionic detergents of the order of 30 t. A short study has supplied useful information on variations in the detergent concentration in sewage. Our study has essentially covered the investigation of these detergents in the sea and their systematic quantitative assaying. On the basis of large grouped series of samplings, maps have been compiled which show, in quantitative terms, the dispersion and persistency of these detergents from the sewage outlet to the open sea. The heavy fluctuations in surface distribution made it possible to show the movements of the mass of polluted water under different weather conditions and to gain a better idea of areas of maximum pollution. This study, which has been performed mainly at the surface, has been amplified by one on distribution in depth which brings out certain stratification anomalies.

EFFECTS OF POLLUTION ON FISH SPECIES DIVERSITY IN GALVESTON BAY, TEXAS

E-71

by

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A correlation of fish species diversity with percent waste water in Galveston Bay, Texas indicated that those areas receiving the greatest amounts of effluent and toxic materials exhibited the lowest mean annual diversities. Fish diversity in the Houston Ship Channel above Morgan Point can be used to predict diversity in the bay because of the linear relationship between distance and dilution of the ship channel effluents.

Sampling throughout the system indicated that the fish populations could be divided into somewhat separate communities, each structured as a response to environmental and pollution stress. In those areas receiving the greatest stress, the bay anchovy, Anchoa mitchilli, was the dominant species. These same areas also supported the fewest numbers of large individuals.

Increased use of Galveston Bay as a receptacle for industrial and domestic wastes could result in further water quality degradation. Community structure could be altered so that the anchovy could very well become the dominant fish species throughout this estuary.

A POLLUTION SURVEY OF THE TRONDHEIMSFJORD, A FJORD SYSTEM INFLUENCED BY SEWAGE AND PULP MILL INDUSTRY

E-72

by

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An attempt was made to combine different standard oceanographic techniques to indicate the type and degree of pollution of fjord systems. The fjord selected has various sources of pollution, including domestic sewage from cities, drainage from agriculture and mining industry, and industrial sewage from pulp mills. Three types of effects and their sources are demonstrated: eutrophication, particulate and mercury pollution. The effect of the fjord hydrography on the distribution and accumulation of pollutants is discussed.

THE DISPOSAL OF CONTAINERS WITH INDUSTRIAL WASTE INTO THE NORTH SEA - A PROBLEM TO FISHERIES

E-73

by

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Containers with various contents of waste from the chemical industry are being recaptured by trawlers in the North Sea. The gravity of this problem is evident from the great number of recaptures and the toxicity of most of the contents. The use of the North Sea for such disposals is discussed.

CANADIAN EXPERIENCE ON SEWAGE POLLUTION OF COASTAL WATERS: EFFECT ON FISH PLANT WATER SUPPLIES

E-74

by

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The indiscriminate discharge of raw sewage into coastal waters has created a serious pollution problem. Even in coastal areas with small populations, the shoreline waters have moderately high coliform counts. In eastern Canada sewage pollution has resulted in the closure of more than 50% of molluscan shellfish growing areas.

An adequate and controllable source of approved water is an essential requirement in site selection for a fish processing plant. Supplies of fresh water are often unavailable and established or developing fish processing industries are dependent upon salt water to meet plant requirements of approximately 10 gal/lb of fillets processed. In Canada all sea water supplies used in fish plants are required to meet a bacteriological quality standard equivalent to the World Health Organization standard for potable water and an increasing number of plants are experiencing serious difficulty in obtaining source supplies which do not require pre-treatment. Harbour waters in urban areas are generally grossly contaminated and treatment costs are prohibitive for their use in fish processing plants. The use of approved municipal supplies is recommended whenever they are available. A major oversight has been the disposal by municipalities of sewage into the marine environment without consideration of the multiple use concept for coastal waters. Recently Water Authorities have been established for the abatement and prevention of pollution.

A typical coastal area situation is described to illustrate the type of sanitary and bacteriological surveys required to evaluate a plant water supply source. Canadian standards and treatment criteria for fish plant water supplies are described.

BIOCHEMICAL STUDIES OF MARINE PHYTOPLANKTON IN THE PRESENCE OF DDT

E-75

by

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Uptake and metabolism of p, p' DDT were studied in seven species of marine phytoplankton. Analysis was done with the use of electron-capture gas chromatography. These species were representatives of five algal divisions: *Skeletonema costatum*, *Thalassiosira fluviatilus*, *Cyclotella nana* (Bacillariophyta); *Coccolithus huxleyi* (Chrysophyta); *Amphidinium carteri* (Pyrrophyta); *Dunaliella tertiolecta* (Chlorophyta); and *Porphyridium* sp. (Rhodophyta). Rates of cell division of five species of the seven were unaffected in 80 ppb DDT. *S. costatum* and *C. huxleyi* exhibited lag phases in the same concentration, after which cell division rates were the same as controls. In 250 ppb DDT, these two algae reacted similarly after a longer lag phase.

The effects of p, p' DDT and p, p' DDE on photosynthetic and mitochondrial electron transport were investigated. This transport was measured in isolated chloroplasts with the use of the electron acceptors, ferricyanide and NADP. Both compounds inhibited electron transport at concentrations ranging from 10^{-6} to 10^{-4}M (0.3 to 35.5 ppm); 50% inhibition occurred at 2×10^{-5}M. The stoichiometric relationship between electron transport and phosphorylation remained the same, indicating that DDT and DDE are not uncouplers. The inhibition caused by DDT was not overcome by the addition of the uncouplers, ammonium sulphate and carbonyl cyanide metachlorophenylhydrazone. This suggests that the site of action of DDT is in the electron transport chain between the two photosystems or at the water-splitting mechanisms. Sonication of chloroplasts significantly increased the degree of inhibition. Similar concentrations of DDT and DDE inhibited electron transport in isolated mitochondrial particles.

THE ASSOCIATION OF DDT RESIDUES WITH LOSSES IN MARINE PRODUCTIVITY E-76

by

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The Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service has been monitoring selected estuarine areas in a cooperative program with state and university marine laboratories for the past 5 years. Samples of oysters or fish are collected monthly at about 150 permanent stations on the American Atlantic, Gulf and Pacific coasts. Chromatographic analytical methods are employed to quantify, with a sensitivity of about 10 µg/kg, the ten most commonly used chlorinated hydrocarbon pesticides as well as some of the chlorinated biphenyl compounds. Samples collected by the Texas Parks and Wildlife Department in one estuary have contained relatively high residues of DDT and its metabolites throughout the course of the monitoring program. The analytical results of these samples plus correlative data on DDT usage and pesticide residues in river water and sediments are presented to show the presumptive causal relationship between the agricultural use of DDT in the associated drainage basin and pesticide residues in the estuarine biota.

Documented regional declines in productivity of the speckled seatrout (Cynoscion nebulosus) in this estuary, as shown by annual fish census studies, are attributed to the inhibition of development in sac-fry embryos by DDT residues in the yolk.

Data are presented to support the hypothesis that estuarine areas and river deltas are probably major depositories for the persistent pesticide chemicals which have been applied world-wide in the past 25 years.

ELIMINATION OF OIL SLICKS IN THE OCEAN BY MEANS OF SOLIDIFICATION

E-77

by

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Objective: A new process is proposed for eliminating oil slicks in the ocean by solidifying the oil through the use of paraffins having a high molecular weight and solid at room temperature.

Basis: The process is based on the transformation of the oil from a liquid to a solid state by using paraffin hydrocarbons as agglomerants. The mechanization triggering this change from liquid to solid state is determined by the change in temperature and the affinity of the paraffins for the hydrocarbons which persist in water.

Utilization of the method: Paraffin residues from the refinery with a melting point of between 50 and 60°C are sprayed in a melted state over the oil slick. The difference in temperature with respect to the water results in the solidification of the paraffin which, due to its affinity for hydrocarbons, totally absorbs the oil. The quantity of paraffin necessary to reach adhesion is 20 to 40%. The resulting mass is inert, harmless to marine life and may be recuperated from the water with nets or raked off the surface.

Advantages: The solid product is completely recoverable, free of water, harmless to marine life, and large quantities of paraffin residues are available at low cost. Afterwards the water remains perfectly clean and free of toxic substances.

Application: Practical experiments were carried out on the ocean and the results confirmed by Spanish naval authorities. This process can be used for preventive treatment, for cleaning port waters and in case of shipwrecks.

POLLUTION : LOSS OF AN $18-MILLION/YEAR SHELLFISHERY

E-78

by

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The loss of a shellfishing industry in the Raritan Bay area, a 57 mi^2 estuarine complex located between the States of New York and New Jersey, was directly caused by discharges, from both states, of inadequately treated municipal and industrial wastes. Municipal wastes, of fecal origin, contaminated bed areas to a point where a serious hepatitis outbreak occurred. Industrial discharges tainted the bivalves and, in certain areas, produced a toxic environment that virtually eliminated propagation.

In order to restore the waters of the Raritan Bay area to a quality consonant with its designated best use, shellfishing, the Federal Water Pollution Control Administration began an intensive 13 month investigation as well as a 3 year surveillance programme. The study involved in-depth sampling and analysis of industrial and municipal effluents as well as the receiving waters. Chemical, biological and microbiological programmes were included in all phases. New analytical techniques and methods were developed for analyzing pollutants in an estuarine environment. Microbiological investigations included analyzing and determining levels of indicator organisms, and detecting pathogens in the shellfish meats as well as in the overlying waters. Dye injected into the major sources of pollution demonstrate that pathogenic organisms were more prevalent in areas which received direct discharges or were influenced by tidal action and currents.

The engineering and scientific data helped in developing recommendations to both States regarding the measures needed to restore water quality in Raritan Bay. Included in these recommendations were specific requirements for minimum treatment for municipal and industrial wastes; minimum and maximum allowable limits for certain toxic elements; and expected dates for implementation of the remedial programme.

THE EFFECTS OF EFFLUENT DISCHARGE ON THE CONCENTRATION OF NUTRIENTS IN THE SARONIKOS GULF

E-79

by

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During a cruise to the Mediterranean of the R/V THOMPSON in March 1970, the pattern of nutrient concentration in the upper Saronikos Gulf was studied using an underway data acquisition system. Seawater pumped from a depth of 3 m was analyzed continuously for the concentrations of nitrate, ammonium, silicate, phosphate and chlorophyll. The data were digitized and punched automatically onto paper tape at 1 min intervals as the ship steamed over a prescribed course. Upon completion of the course, the data were read into the shipboard IBM 1130 computer, and a map of each of the properties measured was produced on a CalComp plotter through a computer contouring program. From two sets of these maps, the regions directly affected by the Keratsini sewage outfall just west of the entrance to Piraeus Harbor have been defined. Two contrasting conditions were seen: 1) a plume of high nutrient and high chlorophyll concentration near the coast of Salamis Island, and 2) a concentric pattern of high nutrients and high chlorophyll with its center in the vicinity of the outfall. Considerable difference in the ratios of the nutrients was observed. It appears that under certain wind directions, the effluent may be driven first into the Gulf of Salamis where the activities of phytoplankton modify the nutrient content. The plume along Salamis Island was apparently produced from this partially "processed" water from the Gulf of Salamis. The unusual nutrient ratios in this plume made it possible to conduct several experiments to evaluate hypotheses on nutrient uptake processes and nutrient limitation of phytoplankton growth in the Mediterranean Sea. The results of these experiments are presented and evaluated.

THE SCIENTIFIC BASES REQUIRED PRIOR TO THE ADOPTION OF LEGISLATIVE MEASURES AGAINST POLLUTION OF THE SEAS

E-80

by

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A law which enforces expensive and difficult measures can be accepted and efficient only if its usefulness is understood, if the technical and scientific bases are accurate, and if it is uncontestable by the pressure groups (e.g. private and public industries, municipalities) which will be involved. It is essential that all the scientific and pseudo-scientific arguments which may be put forward by the interested parties should be dismissed on the basis of meticulous studies. The law should then be based on the following studies:

From the economic point of view, the cost of marine pollution and the measures to be taken against it should be evaluated. From the technical point of view, a list of pollutants should be compiled, their effects ascertained and the techniques of combatting pollution evaluated. From the biological and medical points of view, it is necessary to study the autoepuration and antibiotic capacities attributed to the sea, as well as the microbial aspect of pollution.

A PRELIMINARY STUDY OF SALMON MOVEMENTS IN A POLLUTED ESTUARY E-81

by
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Salmon (Salmo salar L.) movements were studied by sonic tracking in the estuary of the Miramichi River system, the most important Atlantic salmon producer in Canada, in 1969. Pollution from industrial and urban effluents was measured and correlated with hydrography of the estuary and salmon movements. The Miramichi estuary is partially mixed with a flushing time of about 10 days. Variations of vertical salinity gradients in the upper estuary indicated relatively uniform conditions of low salinity at the end of ebb (1.3 to 4.3‰ from surface to bottom) and stratified conditions at the end of flood (4.2 to 13.8‰).

Pollution was surveyed by ultraviolet absorption spectroscopy. Absorbence of water samples increased smoothly with decreasing wave-length indicating the presence of a complex mixture of organic compounds. Absorbence values $A^{1cm}_{250\ m\mu}$ ranged from 0.3 to 0.9 in the upper part to 0.1 to 0.5 in the mouth of the estuary. Correlation of salinity and absorbence was less significant in the industrialized part of the estuary, indicating the heterogeneous distribution of pollutants. Salmon carrying sonic capsules with distinctive signals were tracked for several hours. Positions of others were observed periodically. The experiment extended over six weeks. There was much to-and-fro movement associated with rising and falling tides. Common areas of delay or turning about were near known points of industrial pollution. Within the industrialized part of the Miramichi estuary resultant upstream movement was noticeably slower than in an adjacent smaller, unpolluted estuary. Once fish got above the industrialized part they moved rapidly out of the study area.

DISPERSION OF SEWAGE AND DISAPPEARANCE RATE OF ENTERIC ORGANISMS IN COASTAL WATERS E-82

by

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Information on the disappearance rate of bacteria along the Mediterranean coast is scant. Reliable information can be obtained by simultaneous tracer and microbiological measurements on existing sewage outfalls. The purpose of this study was to measure the physical dilution of sewage and relate it to bacteria concentration. Radioactive tracers were used for determining the dispersion of sewage in the sea. A solution of $K^{82}Br$ was injected into the sewage, which was discharged into the sea. The activity of the resulting radioactive cloud was continuously mapped. Simultaneously, samples of sea water were taken to the laboratory where the coliform density was determined by the milipore filtration method.

From the measurements of the radioactive cloud a dilution map was constructed. The ratio of the "physical" dilution, obtained by the tracer experiment, to the bacterial dilution was determined. This ratio was plotted versus travel time of the sewage from the outfall, in order to obtain the bacterial disappearance rate. Experiments were set up in the laboratory to study the die-away rate of coliforms from sewage in sea water, in the sunlight and shade. The results of these experiments aid in explaining the high rate of bacterial disappearance.

An analysis of the experimentally found dispersion pattern and of the kinetics of bacterial disappearance is presented. The coliform bacteria concentration is compared to the presence of salmonellae and enteroviruses in the same investigated area.

INFORMATION REQUIREMENTS FOR RATIONAL DECISION-MAKING IN THE CONTROL OF COASTAL AND ESTUARINE OIL POLLUTION

E-83

by

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Major oil spills from tanker accidents or from offshore wells discussed in this paper have occurred in areas where seasonal composition of aquatic species was imperfectly known. Also, the effects of oil-control procedures including application of dispersant chemicals, agglomerative materials, or sinking agents upon aquatic species or their habitat were largely unknown.

Under these conditions of ignorance, it is not surprising that government agencies or private companies decided to use chemicals or other materials which caused extensive losses of marine organisms. Furthermore, the urgency of immediate action to limit the spread of oil, and the intense public reaction usually precluded an orderly search for avialable information concerning species composition or possible adverse effects of various control methods.

It is apparent from experience with recent major spills that two main areas of knowledge are needed to permit timely, rational decisions regarding the selection of methods and procedures for control or clean-up of oil spills:

(1) A "Resource Atlas" summarizing available knowledge concerning seasonal species composition in coastal and estuarine areas, especially those in which oil spills are most likely and providing available information about water movements.

(2) A summary of knowledge concerning the "Biological Effects" of various chemical or physical materials proposed for use in control of oil spills upon important aquatic species in each coastal or estuarine area.

Compilation of the proposed "Resource Atlas" and "Biological Effects" series would obviously disclose gaps in knowledge which could then be filled through appropriate research programmes.

With immediately available knowledge of the species expected to be present and their tolerance to various oil-control materials, the administering agency or company could make more rational decisions regarding appropriate procedures for control of pollutants with minimum damage to living marine species. The same kind of information would be helpful in reaching decisions regarding pollution from other hazardous materials.

THERMAL POLLUTION: USE OF DEEP COLD NUTRIENT-RICH SEA WATER FOR POWER PLANT COOLING AND SUBSEQUENT AQUACULTURE IN HAWAII

E-84

by

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Due to the ready access to deep cold ocean water off the Hawaiian Islands, it has been proposed by the authors, that such water be used as cooling water for electric power plants in the State of Hawaii instead of surface water, presently used. This would substantially reduce the volume of cooling water required by the plants by virtue of increased efficiency of the condensers and should also eliminate thermal pollution of coastal waters. Moreover, due to the high nutrient content of the deep water, the effluent cooling water would subsequently be used in a circulating pond system for aquaculture with a variety of suitable crops.

As a step in determining the feasibility of initiating a pilot study based on these principles, investigations have been made on the potential productivity value of deep water taken off the Island of Oahu, Hawaii. Parameters of investigation included carbon fixation (^{14}C-method), plant pigment production and nitrate and phosphate analysis. Test organisms were two chlorophytes, a cyanophyte and mixed phytoplankton populations.

When 500 m deep water was compared to nearshore water under surface level light and temperature conditions, the productivity in the deep water exceeded the productivity in surface water significantly. The carbon fixation by Dunaliella tertiolecta in 300 m water exceeded fixation in surface water by a factor of 2.75 while the 600 m water demonstrated a 16.78 fold increase.

MONITORING OF CREEPING OVER-FERTILIZATION IN THE BALTIC

E-85

by

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Marine pollution studies are generally carried out in areas where the natural biome already has undergone notable changes. In closed basins a need exists for monitoring the productivity of natural biomes and thus at the earliest possible stage getting indications of over-fertilization and pollution besides having the possibility of checking an unwanted development. The pollution of the Baltic Sea has become a matter of interest at the present time. It is almost generally accepted that this brackish water area has a certain limit of tolerance. In Finland the pulp mill industry has been blamed as the main disturber of the natural conditions, but attention has recently been paid also to sewage and to the oil pollution threat.

The biology of several organisms has been thoroughly studied, but little is known of their productivity or of the brackish water communities especially in the littoral benthos. An IBP research programme, started in Finland by the IBP-PM National Project at the mouth of the Gulf of Finland and in the Bothnian Bay, aims at the establishment of a parameter of the productivity of unpolluted Baltic areas.

The littoral benthos is studied with new quantitative sampling methods developed by the Finnish IBP-PM Group. Primary productivity and phytoplankton as well as the profundal zone are worked out sing traditional methods. Three to five 2-week periods of sampling are carried out yearly in both areas of study. The sampled material of animals and plants is identified to the species level; fresh weight, dry weight and ash weight and the contents of the assimilation pigments are registered. A continuous monitoring of the most essential dates is planned.

EXPERIMENTS ON COMBATTING ACCIDENTAL RELEASE OF OIL E-86

by

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Experiences with emulsifiers and dispersants to deal with floating oil (Hellmann)

The difference between emulsifiers and dispersants in breaking up an oil slick into fine, dispersed droplets is described. With the object of finding out the most effective and economical product, laboratory tests were carried out. Three products revealed themselves satisfactory. In order to examine if similar effects could be reached under natural conditions, 12 t of crude oil were dumped into the sea and sprayed with a dispersant which had been diluted with water. Due to the small amount of air and water turbulence, the dispersing effect could not fully develop. Nevertheless, the result was acceptable because, above all, the speed of the spreading oil could be accelerated and the water-in-oil emulsion could be hindered.

Burning off of floating oil (Marcinowski)

In July 1969, the Dutch Rijkswaterstaat made two experiments to burn off weathered light Arabian crude oil floating on the sea and on beaches. The product used was Kontax, consisting of a floating mixture of carbide together with an alkali-metal compound. The first component produced, in contact with water, a strong heat which favours the evaporation of oil components, forming at the same time the inflammable acetylene. The mixture thus produced was ignited by the alkali-compound in contact with water. The burning, started this way, continued by itself because of the increased oxygen suction due to the large flames produced. A very high percentage of the floating oil was burnt off and the underlaying sand in the land experiment contained only small quantities of organic matter.

SANITARY CONTROL OF SHELLFISH AND MARINE POLLUTION E-87

by

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The National Shellfish Sanitation Programme, its basic philosophy, problems, and accomplishments are discussed. The National Shellfish Sanitation Programme was organized in 1925 for the prevention of shellfish-associated disease by means of a programme of stringent sanitary control over growing, harvesting, processing, and marketing of shellfish (oysters, clams, and mussels). It is a cooperative programme composed of the States, shellfish industry, and the Federal Food and Drug Administration.

Growing area control is the programme's principle consideration as a barrier to shellfish-borne disease. Increasing population and industrial growth in coastal areas and accompanying pollution adversely affects shellfish-growing areas. Such pollution presents a broad range of health hazards which include pathogenic bacteria and viruses, pesticides, and heavy metals. Growing area protection involves comprehensive surveys for actual and potential pollution sources and quantities, hydrographic studies, and bacteriological and chemical analysis of the growing waters and shellfish. Growing areas not meeting approved criteria are closed and patrolled to prevent harvesting of polluted shellfish.

Research relative to improved growing area standards for protection against industrial and domestic pollution and controlled purification is on-going. Bacteriological standards for shellfish growing waters, growing area standards for chlorinated pesticides and radionuclides in shellfish meats, and bacteriological standards for shellfish meats at the wholesale market level have been established. Growing area standards for heavy metals in shellfish meats are currently being developed.

CHLORINATED BYPRODUCTS FROM VINYL CHLORIDE PRODUCTION: A NEW SOURCE OF MARINE POLLUTION

E-88

by

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The unwanted byproducts formed when chlorinating aliphatic hydrocarbons amount to at least 75,000 t per year in Northern Europe alone. These are commonly dumped into the sea or burned at sea in special vessels. The rate of accumulation of C-C1 in living organisms was studied, as well as the degradation and solubility in sea water. Estimations of the C-C1 were done on samples of sea water and marine organisms collected during cruises, and from land stations in the North Sea, along the Norwegian coast and in the Barents Sea. Laboratory experiments dealing with the acute effects of C-C1 were performed on algae, invertebrates and fish in order to establish the data needed to assess possible harmful effects. The preliminary data indicated that the highest concentration of C-C1 found in the open sea was about one-tenth of the lowest value found to cause an unmistakably acute biological effect.

OIL SPILL AT SANTA BARBARA, CALIFORNIA : PHYSICAL AND CHEMICAL EFFECTS

E-89

by

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Oil from a well blowout in Santa Barbara Channel entered the marine environment in early 1969. Portions of the heavy fraction were deposited at the sediment-water interface in the vicinity of the blowout. The remainder was transported from the source by a combination of wind and water currents ultimately to be deposited on the beach or at the sediment-water interface in other parts of the basin. Suspended sediments carried by run off from a major flood entered the system immediately prior to and after the well blowout. Adsorption of oil on the flocculated suspended particles followed by deposition was a major factor in carrying much of the oil to the sea floor. Subsequently, a yet to be determined percentage of this material was re-transported to other areas. Chemical analyzes of samples collected in a time series show that within a period of 4 months oil was present in bottom sediments throughout the basin. Natural seeps in the area also introduced oil into the marine environment and increased the background level of oil in some bottom sediments. A portion of the oil remaining on beach sand, after extensive cleanup operations, was covered by prograding sand and much of it was still buried 11 months later. However, tidally-induced movement of the beach water table tended to disperse the original layers of oil, thereby reducing the resistence to erosion normally exhibited by unaltered oil layers.

MERCURY AS A HYDROSPHERIC POLLUTANT
II. BIOLOGICAL HALF-TIME OF METHYL MERCURY IN FOUR MEDITERRANEAN SPECIES: A FISH, A CRAB, AND TWO MOLLUSCS

E-90

by

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Analysis of the excretion rates of methyl mercury introduced by different ways into four marine organisms (Serranus scriba Cuv., Carcinus maenas Rath., Tapes decussatus L. and Mytilus galloprovincialis Lam.) showed that a large fraction of the administered compound has a slow loss rate with a biological half-time from 267 (Serranus) till more than 1,000 days (Mytilus). These results were compared with those obtained with some other freshwater, brackish and marine crabs, molluscs, fish and a mammal. It was concluded that phylogenetically related species follow a similar pattern of methyl mercury excretion, with the biological half-time depending on temperature and on the way of methyl mercury's entry into the organisms, being longer after intramuscular injection than after peroral administration.

PRELIMINARY STUDY ON THE DISTRIBUTION AND EFFECTS OF TWO CHEMICAL FORMS OF METHYL MERCURY IN PIKE AND RAINBOW TROUT

E-91

by

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This experiment was performed in order to establish:

1) Any possible difference between the "free" ionic form of methyl mercury and the protein-bound form of methyl mercury in the toxicity to pike.

2) Distribution of radioactivity after administration of these two methyl mercury compounds labelled by ^{203}Hg.

3) Pathological and histopathological changes in the organs of the pike after oral administration of the two methyl mercury compounds.

The "free" ionic form was applied as a water solution of $CH_3{}^{203}HgNO_3$ with carrier (0.5 µCi/mg Hg). The protein-bound form was made by adding fresh cow's liver homogenate to the water solution of $CH_3{}^{203}HgNO_3$ with carrier and incubating the mixture for 24 h at room temperature (22°C). It was characterized as true protein-bound methyl mercury by means of an extraction procedure without or with acidification by concentrated HCl and extraction by benzene followed by separation with thin layer chromatography.

The administration was done orally in three to four small doses at intervals of 2 to 3 days. Five pikes (mean weight 300 g) were given ionic MeHg to a final mean total dose of 12.1 mg Hg/kg (retained) and to five pikes (mean weight 340 g) to a final mean total dose of 24.7 mg Hg/kg protein bound MeHg, respectively. In addition, six control pikes with no activity given were kept in the same aquarium. The mean life span for pikes given ionic MeHg was 33 days; for those given protein-bound MeHg it was 18 days.

The approximate value of $LD_{50/30}$ d. for both of these compounds was 15 ± 3 mg Hg/kg fr. wt. The histopathological symptoms of these methyl mercury compounds were similar. Kidneys and pseudobranchiae were the most damaged organs. No noticeable difference was observed in the distribution pattern between these two methyl mercury compounds.

When ionic methyl mercury was orally administered as a single dose to seven rainbow trout (220 g) giving a mean body burden of 11.9 mg Hg/kg, all died within 1.5 to 2 h. When the same amount of ionic or protein-bound methyl mercury was administered in two portions with an interval of 1 to 2 days, only three fish out of 12 died after 47 to 71 days. The others remained seemingly healthy for at least 94 days. The temperature in these experiments was +18°C.

THE EFFECT OF OIL POLLUTION ON FLORA AND FAUNA OF THE BLACK SEA E-92

by

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The study of composition and quantitative distribution of micro-organisms in the presence of oil and oil products was accomplished during 1967-68. The area of investigation included the Western and Central Mediterranean. Sterilized samples of surface water were collected on the 54 stations. Cultivation of micro-organisms was made at 27°C and the sterilized oil used was the only source of carbon during the process of cultivation. The ability to develop in the environment in the presence of oil was checked for all cultivated organisms and in 28 cases it was proved positive. The species were determined according to N.A. Krasilnikov. Most of them are of Pseudobacterium, Micrococcus, Pseudomonas bacterium and Bacillus families.

A MONITORING SYSTEM FOR ENVIRONMENT CONTROL E-93

by

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In Western Europe, many countries now have legislation to safeguard water supplies from excessive pollution; but there is very little continuous information on status. Continuous measurement systems require quantitative hydrological and meteorological information, and data on certain physical quantities and biochemical effects. The systems should monitor the course of pollution and the effect of measures taken to inhibit pollution.

We suggest a system of slave stations in the field from which data on activity of pollutants at different limited environment areas could be transmitted to primary stations for the first step of logging. The primary data also could be transferred to national data centres. A system of slave stations, primary stations, and local - regional - national data centres would give different authorities information for managing the pollutants on local, regional, and national levels.

We have begun and are planning more activities to measure properties of air, surface water and ground water with selected sensors and to telemeter the data. The air system sensors measure sulphur oxide, carbon monoxide, carbon dioxide, nitric-nitrous oxide and suspended particles. Sensors are being developed for specific components of automobile exhaust gases. Different combinations of surface water sensor systems are possible. A complete set will measure wave height, current speed and direction, water temperature, conductivity, dissolved oxygen, dissolved chlorides, oxidation - reduction potential, turbidity, suspended matter, total organic carbon and pH. The ground water sensors measure water level, temperature, conductivity and pH. Water sensors are being developed not only for physical - chemical pollutants but also for identifying biota, e.g. specific bacteria analyses.

Overall national monitoring systems can interact with other national systems for global data control of the ecological system.

ADVERSE EFFECTS OF MARINE POLLUTION IN JAPAN ON QUALITY AND MARKETS OF FISHERY PRODUCTS

E-94

by

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The work carried out at the Tokai Research Laboratory demonstrates the effect of industrial pollutants on the odour, taste and colour of fishery products.

It has been demonstrated in the cities of Yokkaichi, Iwakuni, and Mizushima that the effluent from oil refineries, petrochemical plants, and vessels produce offensive odours in fish and shellfish. In some instances this odour is detectable in fish taken as far as 10 km from the city (Yokkaichi). It has also been demonstrated that pulp mill effluent causes off odours in fish.

A particularly bitter taste was found in soft shell-clams taken in the estuary of the Ohmuto river which could be attributed to industrial effluents. Green discolouration of oysters, caused by high concentrations of copper and zinc in industrial effluents was found in the vicinity of industrial cities such as Hitachi and Nobeoka. A number of instances have been observed when the fish which command a high price in Japan have been killed by polluted water when stored in boat holds and live fish preserves in fishing ports.

INTERFERENCE WITH FISHING OPERATIONS BY MARINE POLLUTION IN JAPAN

E-95

by

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Frequently, solid materials such as plastics are caught in the small trawl nets in Tokyo Bay and other embayments. Sometimes more solids are caught than fish and it frequently becomes impossible to draw the nets. In Osaka Bay, objects dumped by barges are caught by the nets. Other industrial solid wastes, such as pitch sulphate in particular, are caught together with fish and the fish are unmarketable.

The laver (edible seaweed), Porphyra tenera, gets carcinomatous disease from industrial effluents, therefore, its culture has been stopped in the waters near the coast of the industrial area of Ohmuta Bay. Mineral oil released deliberately or by accident, and fats and oils in the effluents of food-processing factories, not only harm the laver itself but these oils stick to the culture nets and disturb fish culture operations. Red tides, "blooms" of phyto-plankton caused by eutrophication, frequently injure the fish cultured in Tokushima Bay.

MULTI-SPECTRAL REMOTE SENSING FOR MONITORING OF MARINE POLLUTION

E-96

by

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Within the last decade, multi-spectral measurements of the ocean surface have been made with remote sensors covering the whole range of the electromagnetic spectrum from the near ultra-violet, through the visable and infrared, and into the microwave region. Measurements, observations, and experiments have been carried out at heights ranging from sensor mounts on board ships to satellite altitudes. Sensor sophistication has ranged from a simple incident light meter to complex multi-spectral imaging systems requiring computer facilities for data display and analysis.

Demonstration experiments have been carried out to test the feasibility of: relating water colour to chlorophyll concentration; mapping oil slicks by measurements in the near ultra-violet, thermal infrared, microwave portions of the spectrum; and mapping coastal currents through colour photography and thermal imagery. The results of these experiments have shown that a technical capability exists for meaningful multi-spectral measurements in oceanography and fisheries. The development of operational systems specifically designed for oceanography, such as the suggested Multi-channel Ocean Colour System (MOCS), Thermal Infrared Mapping System (TIMS), and the All-Weather Ocean Dynamics System (AWODS), now depends upon a close interaction between the instrument designer and disciplinary user for definition of measurement requirements.

The results of demonstration experiments suggest that it is now possible to develop relatively simple single purpose instrumentation to map oil slicks, thermal plumes, and sediment loads from aircraft for particular applications. Increased capability for monitoring of marine pollution will evolve as the early applications experiments allow the users to gain experience and to obtain a data base for the development of environmental models of increased sophistication. The new models will permit the user to revise his specifications for measurement requirements and to thereby obtain new instrumentation for an improved capability for pollution monitoring and environmental research.

MARINE POLLUTION STUDIES IN HONG KONG AND SINGAPORE

E-97

by

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Both studies are at present proceeding and firm conclusions have not yet been reached. The paper describes the events leading to the investigations, the problems confronting the governments concerned and their consulting engineers, and the objectives and methods used in the survey work.

The Hong Kong study was directed to examining the extent and effect of existing crude sewage discharges in Victoria and Tolo Harbours, and to assessing the ability of these and adjacent waters to assimilate future discharges of crude or treated sewage without damaging effects. Methods used included current metering, float tracking, bacterial tracers, bottom sampling, and measurement of salinity, temperature and dissolved oxygen.

In Singapore, the investigation was directed to determining if sewage wastes or sludges can be discharged safely into the sea and assessing the danger of oil pollution from local refineries and tanker movements. Methods similar to those in Hong Kong are employed, and the study will include relevant aspects of meteorology and geology and consideration of the feasibility of construction work on the sea bed.

RESULTS OF AN OIL-POLLUTION REPORTING SCHEME OF THE NETHERLANDS LIGHTVESSELS

E-98

by

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As regards the pollution of the sea by oil, catastrophic cases naturally draw general attention. However, the more or less regularly occurring pollution on a moderate to small scale deserves attention as well. Information from coastal stations cannot be used for the assessment of the degree of pollution of the sea. Coastal pollution depends on the direction of the wind and for this reason reports on pollution of the beaches may give a wrong impression of the situation at sea. A regular reporting scheme for oil pollution has been in operation since 1963 aboard the Netherlands lightships. The results obtained from these observations will be discussed. The general outcome of this study is that no significant decrease or increase in pollution can be deduced for the Netherlands coastal waters from the period 1963 to the present time.

THE EFFECTS OF SOLID WASTE DISPOSAL ON BENTHIC COMMUNITIES IN THE NEW YORK BIGHT

E-99

by

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The New York Bight is polluted by 1 billion gal of raw sewage which it receives daily from the Hudson River and smaller water ways. In addition, over 5 million yd^3 of sewer sludge and 6 million yd^3 of contaminated dredge spoils are dumped 17 and 15 mi respectively from the mouth of the Hudson River. These disposal practices have resulted in a biologically impoverished area of 20 m^2. Much of this is devoid of any benthic micro or macrofauna and communities surrounding the impoverished areas have very low diversity and biomass. Many of the taxa which are found in these marginal communities are known to be tolerant of low oxygen and high hydrogen sulphide values.

We have found benthic gammarid amphipods to be good indicators of environmental deterioration; both amphipod diversity and numbers were inversely correlated with levels of contamination. Larger crustaceans including the crabs, Cancer irroratus, and C. borealis, and the lobster, Homarus americanus, were found to become debilitated and diseased when they migrated into the two waste disposal areas. We have been able to duplicate these pathological developments in our controlled environment aquaria. The disease appears to be initiated with fouling of the gills and the branchial cavities. This is followed by the development of severe lesions on the outer exoskeleton and the thin cuticles covering the gills. In most instances the underlying cellular hypodermis is also involved.

The sediments in the biologically impoverished zones are characterized by very high levels of heavy metals, including copper, chromium, and lead, as well as by petrochemicals and organics. Some sediments contained over 30% organic matter. Preliminary information indicates that at least some polychaete worms take up heavy metals. Bacterial decomposition of the organic matter acts to reduce the levels of dissolved oxygen; during the summer months of 1969 and 1970, oxygen was reduced to less than 2 ppm.

The dumping of solid wastes during the past 40 years has seriously affected the ecology of a significant part of the New York Bight.

RED TIDE AND POLLUTION

E-100

by

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The enormous development of dinoflagellates that produce red tide may be attributed to the environmental change caused by the discharge of waste water, namely, altered salinity and the introduction of bacteria (vitamins) and chelating agents. "Potentialized" species reach full development when other factors such as high temperature and calm conditions are present.

Red tide is often responsible for serious disorders:

Respiratory irritations
Food poisoning (through the ingestion of shellfish which have been in this water)
Mass deaths of fish

This leads to the important side-effect of pollution on the economy, tourism and public health, and the necessity to treat sewage with products that destroy chelating agents and vitamins (in particular, by passing it over active carbon).

ON THE INFLUENCE OF INDUSTRIAL WASTE CONTAINING H_2SO_4 AND $FeSO_4$ ON THE BOTTOM FAUNA OFF HELIGOLAND (GERMAN BIGHT)

E-101

by

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Since May 1969 a daily quantity of about 1600 t of waste acid (containing 10% H_2SO_4 and 14% $FeSO_4$ + minerals) have been discharged by special tankers in tankers in an area 11.5 mi northwest of Heligoland. Harmful effects on various marine organisms of the waste acid, even in great dilutions, have been proved experimentally. Research on the ecological effects of this waste acid is being carried out by different German research institutes. These investigations are concerned with influences on the benthic communities (especially macrofauna). There is ample information about the previous faunistic conditions in the research area (Stripp and Gerlach, 1969) and in the southern neighbourhood (Stripp, 1969). The area is part of a medium sand region occupied by a Venus-gallina-community of low biomass.

Since April 1969 regular monthly investigations have been carried out by taking samples by van-Veen-grab in the polluted area as well as in comparison areas. The macrofauna is quantitatively registered and determined; a calculation of growth and age distribution in the population is made by measurements of size or weighing. By dredging and fishing additional qualitative information is obtained, especially about the vagil fauna. The results of one year of research show little alteration in the ecosystem. To recognize significant influences of the waste acid on the benthic community requires long term investigations.

COMPARISON BETWEEN MAPS SHOWING POLLUTION BY CHEMICALS AND THE BENTHIC/PLANKTONIC POPULATIONS OFF MARSEILLES

E-102

by

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The purpose of this study, begun in 1970 and carried out jointly by the Marine Station at Endoume and the ecologists of the Atomic Energy Commission at Pierrelatte, is to show the correlation between chemical pollution (detergents) and the biological evolution of benthos and marine plankton. This evolution can be (1) quantitative, by a diminution of the density of populations of certain species and the modification of the ecosystems, or (2) qualitative, by the disappearance of important species, of others of less value, or by a process of abiotic evolution.

The study was undertaken chiefly for a methodological purpose - to try to find out a system to check the influence of pollution and the definition of areas involved, and thus to protect sea water.

EFFECTS OF PROPOSED SECOND ENTRANCE ON THE FLUSHING CHARACTERISTICS OF SAN DIEGO BAY, CALIFORNIA

E-103

by

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A hydraulic model of San Diego Bay, California, was constructed to study the effects of a proposed second entrance on the hydraulic and flushing characteristics of the bay. The purposes of the second entrance would be to provide shorter and safer access to the ocean for both naval and commercial ships and, if possible, to improve the existing slow flushing rate of the bay.

The model was constructed to linear scale ratios of 1:500 horizontally and 1:100 vertically and was of the fixed-bed type. It was carefully adjusted to accurately reproduce observed prototype tides, tidal current directions and velocities, and the dispersion of dye tracers. Since the waters within the bay and the adjacent ocean areas are essentially homogeneous, it was not necessary to reproduce salinity effects in the model.

Tests were conducted for two different second entrance locations near the south end of the bay. It was found that maximum current velocities throughout the northern half of the bay were generally reduced by about 50% by both plans. The results of dye tracer tests showed that both plans would appreciably improve the overall flushing characteristics of the bay, with the northernmost second entrance producing the most improvement in flushing. With either second entrance in the model, it appeared that the nodal point of the incoming tide was somewhat to the north of the nodal point for the outgoing tide, thus creating a circulation pattern with a net flow into the bay through the existing entrance and a net outflow through the proposed second entrance.

AIRBORNE MEASUREMENT OF OIL SPILLAGES E-104

by

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Oil issuing from leaking wells offshore near Santa Barbara, California, and in the Gulf of Mexico near Venice, Louisiana, was found to take two separate forms; predominantly, the oil appeared in the water as ropey bands, and to a lesser extent as a film on the surface. To the airborne observer the ropey banks appeared thicker than the oil film, but at present there is no technique to determine the thickness of the oil. The movement of oil in both its manifestations was controlled by wind and water currents, although the wind seemed to be the predominant factor at Santa Barbara.

Photographic coverage using black and white, colour and infrared film taken at both high altitude (35,000 ft) and low altitude (1,000 ft), and ultraviolet imagery was obtained. All four types of film were effective in recording the oil at low altitudes although colour film afforded the best results, because it could be used under extremely adverse weather conditions. At high altitudes the infrared film failed to see the oil unless the photograph was taken on an angle which was at or near the Brewster angle. Off the Gulf Coast, near Venice, Louisiana, chemicals were added to the oil as it issued from the well giving the oil an orange colour which could not be recorded effectively by the ultraviolet imagery.

The vast areas involved and the rapidly changing location of the oil present problems in mapping such oil spillages by photography. To adequately map the movement of the oil photographic coverage repeated several times each day is needed, requiring the processing and handling of large amounts of film. Television techniques offer a method whereby data can be screened easily.

Tracking an aircraft by radar while the plane is either observing the oil or photographing it has been used successfully to record the location and extent of the oil while the film shows its nature. A helicopter can be used when visibility is low and permitting direct observation of oil damage.

POSSIBILITIES FOR CONSTRUCTIVE USE OF DOMESTIC SEWAGE (WITH AN EXAMPLE OF THE LAKE OF TUNIS) E-105

by

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Because of various aspects, (aesthetics, hygiene, public and economic pressure for the protection of the tourist trade) sanitary engineering is keeping the coastal zones "clean" of domestic sewage. For this purpose two techniques are used: waste treatment or waste dispersal by outfalls. Both are very expensive but still not efficient enough to prevent marine ecosystems adequately. Disregarding some limited fertilization (insignificant for fisheries exploitation) caused by sewage discharged into open waters by such methods these techniques represent almost total and permanent loss of nutrients in sensu lato. Therefore, considering economizing pollution control, the author advocates advanced experiments in mariculture based on the nutritive value of domestic sewage, and especially concerning the Mediterranean because of particular reasons (low natural productivity, specific menace of pollution to tourism as an important national economy), and because of particular opportunities (richness of adequate coastal formations, lagoons, bays, etc.).

The author defends his theories with results of laboratory experiments on an artificial feeding cycle within heavily polluted environment whose tertiary production might have commercial value. All organisms considered were isolated from the extremely polluted Lake of Tunis which was used in a natural, large-scale experiment giving the strongest argument for the above-mentioned theory. The Lake offers in spite of its uncontrolled eutrophication which causes anoxic disasters accompanied by mass mortality of fish, an average yearly catch of 460 t of fish (115 kg/ha/year for a potential of 100,000 t of ulvas for nutriment and 2,000 t of gracillarias for agar-agar.

DDT RESIDUE LEVELS IN SOME U.S. FISHERY PRODUCTS AND THE EFFECTIVENESS OF SOME TREATMENTS IN REDUCING THEM

E-106

by

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Pesticide residues in food fish and shellfish from waters off the Pacific coast of the United States have been examined to determine the degree of compliance with the U.S. Food and Drug Administration interim tolerance of 5 ppm for total DDT. Sockeye salmon (Oncorhynchus nerka) taken from the open Pacific Ocean south of the Aleutian Islands were also examined. None of the samples from the open ocean or Washington and Oregon contained more than 0.5 ppm DDT. Some samples from coastal waters of southern California, however, contained seizable residues of DDT - up to 57 ppm.

Efforts to remove DDT from jack mackerel (Trachurus symmetricus) by modification of exhausting times and temperatures were not successful. Analyses of individual jack mackerel showed wide variation in residues. Larger fish showed a greater accumulation of DDT.

The residue level in coho salmon from the Great Lakes could be reduced by trimming the skin, belly flap, and dorsal median and lateral line fat.

Processing fish into meal or fish protein concentrate (FPC) provides proteinaceous fish products with low levels of DDT: 0.097-0.6 ppm in meal from menhaden (Brevoortia tyrannus and B. patronus) and less than 0.002 ppm in FPC from Pacific herring (Clupea harengus pallasi). The oils obtained during the manufacture of menhaden meal contained 2.1-9.4 ppm DDT. Oil extracted from Pacific herring processed into FPC contained 0.28 ppm DDT. Methods for lowering the DDT content of unhydrogenated and hydrogenated fish oil have been examined.

POTENTIAL POLLUTANTS WHICH COULD AFFECT LIVING ORGANISMS IN THE MARINE ENVIRONMENT ALONG THE COAST OF PERU

E-107

by

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The present work is an evaluation of possible pollution problems resulting from the discharge of industrial sewage into the sea by the major industries along the Peruvian coast. This refuse, as well as the domestic sewage from the population, presents esthetic problems on the beaches - problems, however, which could be resolved by adequate placing of submarine outlets.

Due to lack of study there is no precise knowledge concerning biological changes in the flora and fauna of the Peruvian coast. In specific cases there is no evidence of change in the normal behaviour of marine organisms; however, it would be necessary to carry out surveys and studies under the guidance of experts and international organizations in order to preserve the normal conditions of this, one of the richest regions in the world in marine life, and taking into consideration future programmes of mining and industrial expansion, especially of exploitation of the sea.

Therefore it is extremely important that international organizations intervene to forbid completely atomic experiments and the dumping of radioactive residues and toxic elements into the Pacific Ocean, considering that this could alter the life of marine populations, which could result in the destruction of the most important future food resources for man and which could also damage the economic position of the countries depending on these resources.

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